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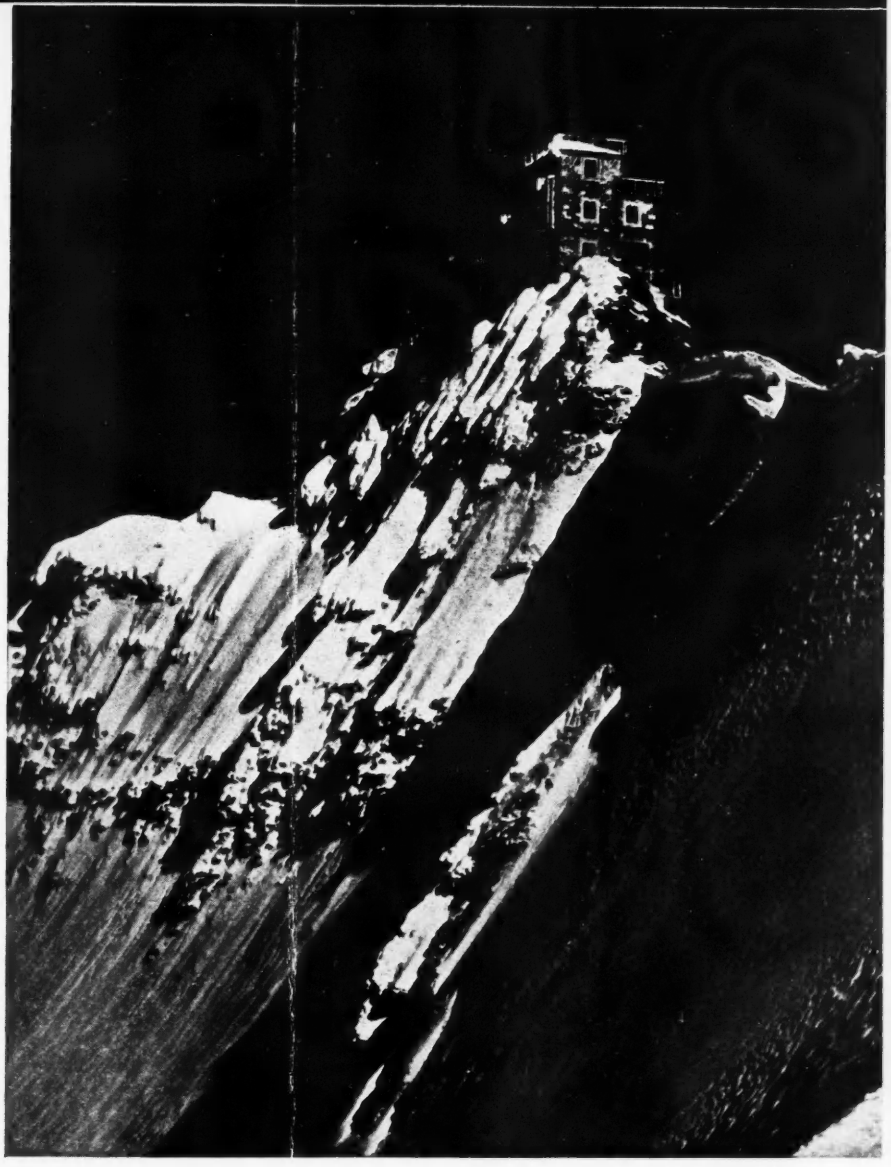

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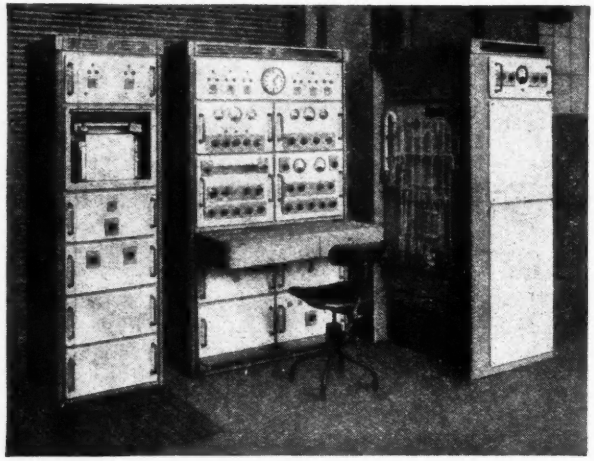

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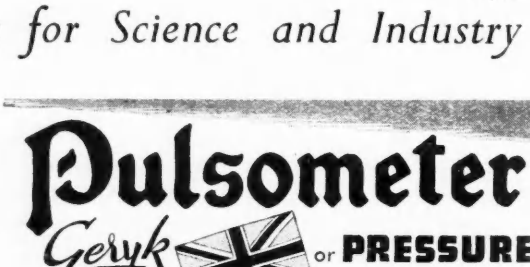

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DISCOVERY

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The Progress of Science

The Beveridge Report

EVERYONE interested in the impact of science and technology on society should read the Report of the Broadcasting Committee—the Beveridge Report, as it is generally called. The power of radio, is, as a commentator pointed out in *The Observer*, a power as great in its way as atomic energy. In the last twenty years we have seen that power used well and we have also seen it abused; in the hands of men like Roosevelt the microphone has been a great force for good, but at the same time it has proved the ideal instrument for such totalitarian propagandists as Goebbels.

The tragedy is that nothing comparable to the tradition of 'the freedom of the Press' has been built up in the case of radio. No Government, so far as we can determine, has given legal force to the concept of 'freedom of speech' so far as radio is concerned, and the concept is not yet hallowed by tradition because broadcasting is so young a medium of communication.

In Britain, broadcasting is a monopoly, and it is hard to see how it can gain its first essential freedom so long as the monopoly is maintained. Only one memorandum submitted to the Beveridge Committee really got down to this fundamental issue; that was the memorandum of Sir Robert Watson-Watt, F.R.S., and Mr. Geoffrey Crowther, editor of *The Economist*. This was probably the most worthwhile piece of evidence submitted to the Committee and we commend it to the attention of all our readers.

As for the Beveridge Report, and its recommendations, we find it impossible to believe that the panaceas put forward—"Decentralisation, Devolution, Federalism," the Committee's own battle cry—will make any very substantial difference to the organisation of the B.B.C. or to the character of the programmes which the B.B.C. puts out.

We may be wrong in thinking this, indeed we hope events will prove us wrong, but it is our firm conviction that the upshot of the implementation of the Beveridge recommendations will be another example of the way things remain the same the more they change. Control will still remain at the centre of the B.B.C. nexus, and we do not believe that the policy controllers in Broadcasting House will be prepared to decentralise, devolve and federalise their power away.

Self-sufficiency in Sulphur

THE cut of one-third in sulphuric acid supplies to all consumers is now producing the difficulties expected and pressure to suspend the manufacture of superphosphate fertilisers for the time being is already perceptible. The likeliest ultimate solution of the shortage now seems clear: the Government will decide to rely on indigenous sources of sulphur.

The main contribution is to come from the specifically British process for producing sulphuric acid from anhydrite (a form of anhydrous calcium sulphate). The only plant operating this process economically is the I.C.I. installation at Billingham, although a Government factory using material mined at Cumwhinton, Cumberland, is believed to have been constructed towards the end of the last war. The process consists in roasting a mixture of anhydrite, coke, sand and ashes containing alumina. The materials are carefully ground to the required size and blended for feeding into the ordinary type of cement kilns—huge rotating cylinders 11 feet in diameter and nearly 100 yards long. Heat is supplied by burning pulverised coal and at a temperature of 1400° C. sulphur dioxide is driven off the anhydrite, the calcium oxide left combining at the same time with the other materials to produce cement clinker. This is cooled and ground to give a high-quality product. The gases driven off contain about 9% of sulphur dioxide. They are cleaned in electrostatic precipitators which use a D.C. discharge at 40,000 volts to throw down the fine dust particles which would otherwise choke the catalyst through which the gases are passed after drying. Here the sulphur dioxide oxidises to sulphur trioxide which passes on to absorption towers to yield sulphuric acid.

The Billingham plant is uniquely situated to operate economically. The anhydrite is mined from a depth of 600 feet inside the works and the coal of Newcastle is on the doorstep. Nearly 20 years' operating experience lie behind this plant which produces 100,000 tons a year or

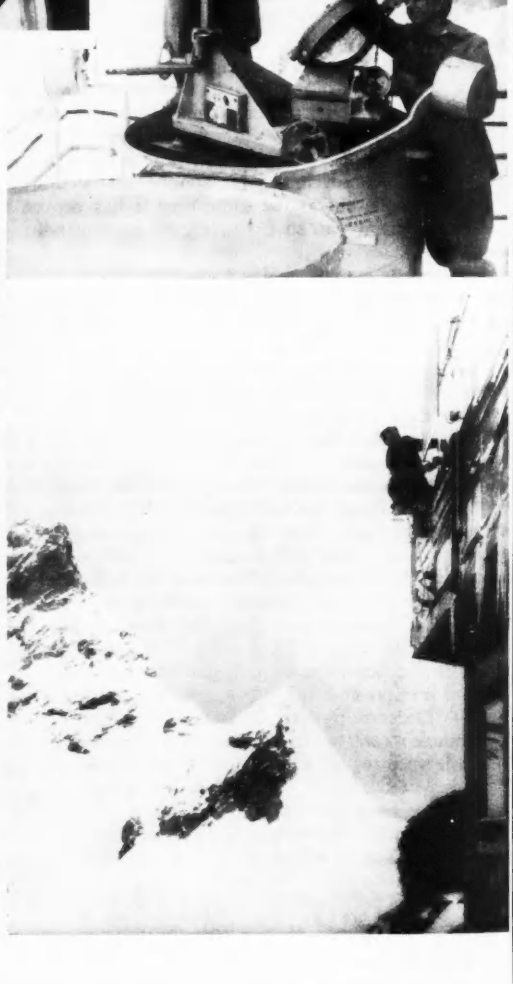
RESEARCH ON THE JUNGFRAUJOCH

FIG. 1 (*left*).—Dr. H. W. Kasemir, German researcher, measuring atmospheric electricity on the roof of the main building of the research station. In the background is the observation tower of the Sphinx Observatory where there is similar measuring apparatus.

FIG. 2 (*below*).—The 'coelostat' on the roof of the Sphinx observatory. Prof. Migeotte (in beret) Belgian professor of physics, is directing the sunlight into the laboratory where he has one of the biggest infra-red spectrographs in the world.

FIG. 3 (*below left*).—The English nuclear physicist Norman Barford at work on the snowy roof of the observatory. Under the mass of lead in the foreground are photographic plates which when developed will show the action of cosmic rays which have penetrated the lead and disrupted atoms in the light-sensitive layer on the plates.

FIG. 4 (*below right*).—Dr. Kasemir adjusting his measuring instruments. The Jungfrau towers above him.



about 5% of the country's sulphuric acid needs. This production requires 165,000 tons of anhydrite and 26,500 tons of coal while 100,000 tons of cement are produced at the same time. The decision to put up more plants of this kind is a serious one because it means more demand for coal, and perhaps its transport some distance which would result in a change in the pattern of cement manufacture and would involve considerable capital outlay. About two years would be needed to get the plants into operation. The gap during that period will almost certainly have to be met by the purchase of sulphur from Sicily. Substantial deposits of anhydrite besides those mentioned are known near Selby, Yorkshire, at Barrow-in-Furness, in Sussex, and elsewhere.

An anhydrite plant at Hamburg is making an important contribution to European supplies of this vital acid.

Research at Eleven Thousand Feet

ONE of the highest laboratories in the world is the Jungfraujoch station, 3456 metres up the Jungfrau. This singularly well-equipped laboratory figures prominently in an article on high-altitude laboratories by Serge A. Korff in *Physics Today*, who writes "Doubtless the finest laboratory in this altitude (9000–12,000 feet) is the Swiss establishment at the Jungfraujoch. This station is accessible by rail. Together with the adjacent hotel, it provides ample accommodation for visiting personnel. Electric power is sufficiently available for almost any physical experiment, including those which require such large current users as cloud-chamber magnets. Ample shop, darkroom, and other facilities exist. The station is connected by elevator with the Sphinx Meteorological Observatory, about 400 feet higher at 11,700 feet. Cosmic ray equipment can be, and has been, operated here too." The station can be used by scientists regardless of their nationality. Thus one finds English scientists working there on cosmic ray phenomena, at the same time as a Belgian is studying solar radiation (with one of the world's largest infra-red spectrographs) and a German is doing research on atmospheric electricity.

Here the term international co-operation is no idle boast, but an accomplished fact.

Britain takes full advantage of the Jungfraujoch station. Indeed to judge from a note in a French journal British workers are a little inclined to monopolise it: "Une seule ombre au tableau: les Suisses, qui, moyennant partage des frais, ont mis l'observatoire à la disposition des organismes scientifiques de France, d'Angleterre, de Belgique et d'Autriche, constatent que l'Angleterre, pays qui se sert le plus de l'observatoire, a déjà une 'ardoise' inquiétante."

A team of four from Manchester University has been working there. This team is headed by Mr. J. A. Newth and includes an Indian, Mr. A. B. Shahiar of Bombay. For this winter's work on cosmic rays a special electromagnet was installed. This was constructed in the Research Department of Metropolitan-Vickers at Trafford Park for Prof. P. M. S. Blackett's Manchester team, which uses it in connexion with cosmic-ray research. The assembled magnet weighs about 14 tons, but for ease of transport it was designed so that it could be moved in small pieces and assembled at the Jungfraujoch station. The heaviest units are the coils, which weigh 450 lb. each. On the last stage of its journey from Interlaken to the Jungfraujoch, the magnet had to travel along three mountain railways. A light crane had to be used to lift the magnet's components on to the roof of the research station.

For cosmic-ray work at this station the photographic technique worked out by Prof. C. F. Powell is specially convenient, because of the portability of photographic plates as compared even with such apparatus as the Wilson cloud-chamber. Special photographic plates can be exposed at the mountain observatory and sent back to Bristol

Postscript to the First A-Bomb

LIKE many scientific people we have been inclined to laugh at those members of the lay public who expressed the belief that an atomic bomb might set up a chain reaction in the earth that would bring universal disaster. But to judge from the following anecdote from the book *Global Mission* by the chief of the U.S. Army Air Force, General H. H. Arnold, which Hutchinson's have just published, it was a scientist connected with the detonation of the first atomic bomb in New Mexico who first expressed the view that atomic bombs might cause unpredictable repercussions.

General Arnold writes:

"We had received word that the Secretary of War wanted to see us. We went over to Secretary Stimson's villa immediately and found Assistant-Secretary McCloy and Mr. Bundy there. They showed us a cable stating that a successful test had been completed with the S-1, which was the atomic bomb, at Alamogordo, New Mexico, on July 16, 1945.

"This did not come as a complete surprise to me, but I had thought the test was a week or two away. From the information we received, the scientists were very pleased with the results. The sound, it was reported, could be heard fifty miles away, and the flash could be seen for over two hundred miles out in the desert north of El Paso.

"*An interesting postscript came to us later, with regard to this test: After all the years the scientists had been working on atomic fission and to develop power and a bomb from that chain reaction, when the set-up was finally completed, all component parts in place, electrical wiring for exploding the bomb ready, and they were only waiting to make sure, for safety's sake, that no one was within the danger area, one of those experts came up in the dark of the morning, grabbed General Leslie Groves by the arm, and said, 'General, for God's sake, don't explode that bomb!' When General Groves asked him why, he replied, 'Because we do not know what will happen! We have no idea what it will do. It may tear off a corner of the earth. Don't for heaven's sake explode it!' That put General Groves in a very unhappy position, but he decided to go ahead, and the first of the atomic bombs was detonated. The results of that test proved conclusively that we had in our possession the means to wipe out completely large areas of an enemy country.*"

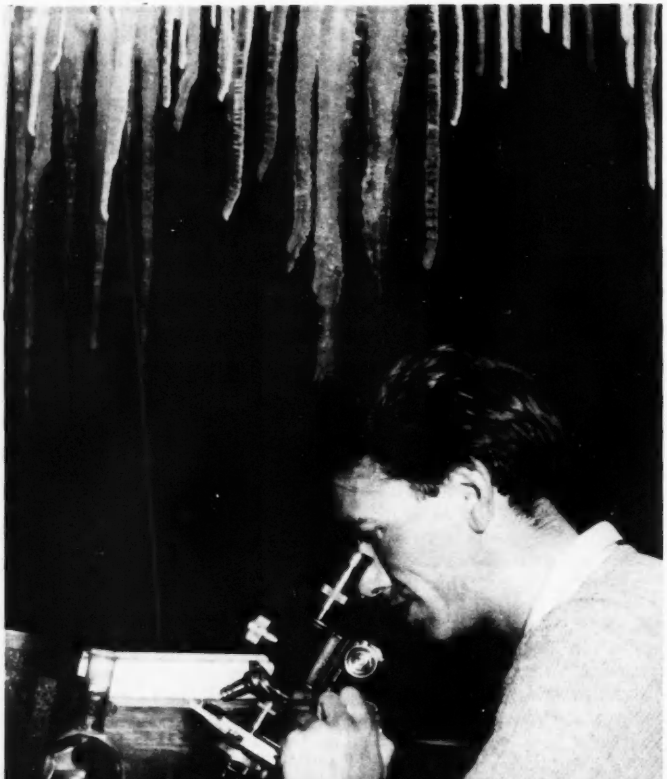
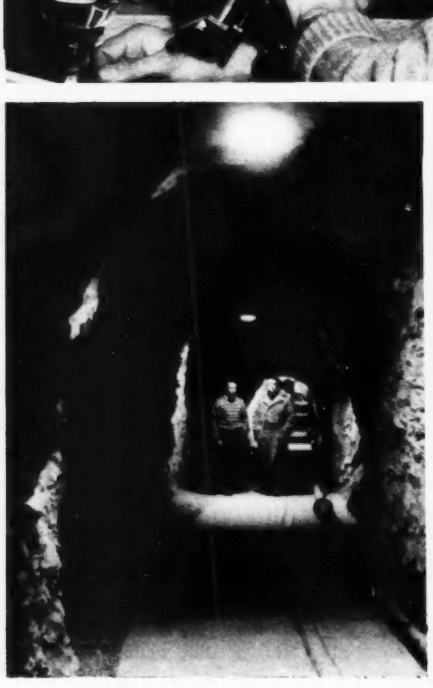


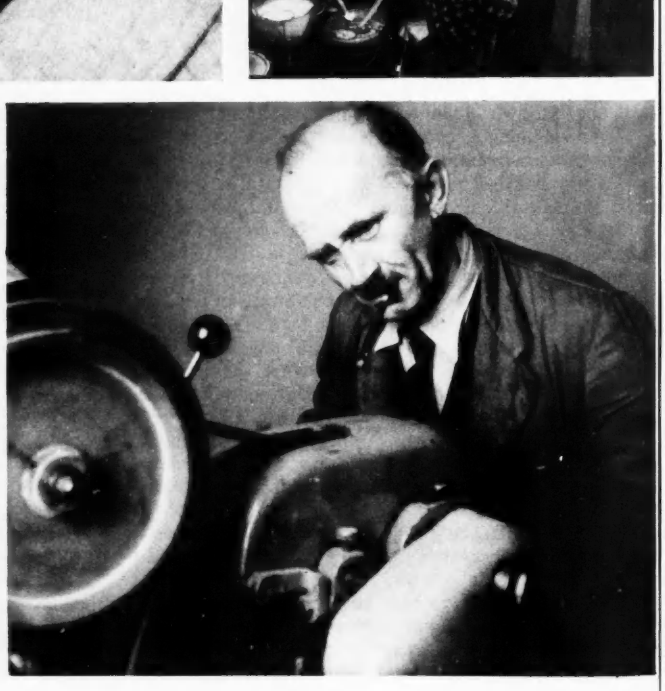
FIG. 5 (*left*).—Norman Barford examining the tracks left by cosmic rays on a photographic plate.

FIG. 6 (*below*).—International co-operation in the kitchen of the Jungfraujoch station.

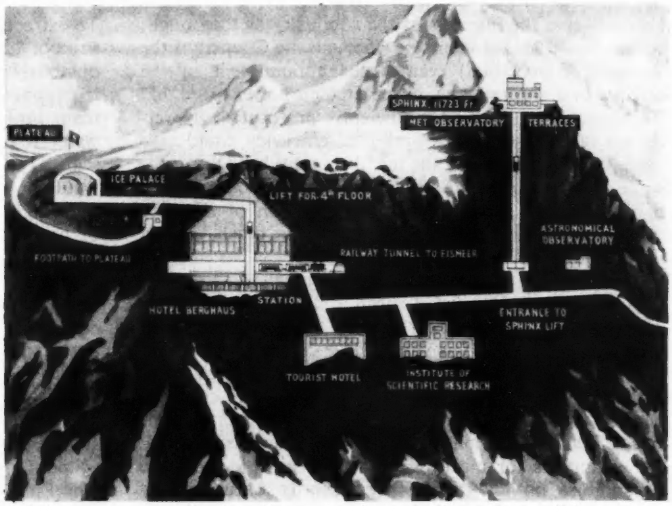
FIG. 7 (*below left*).—Tunnelled out of the heart of the Jungfrau are long passages linking the research stations and hotels.

FIG. 8 (*below right*).—Hans Wiederkehr, caretaker of the Jungfraujoch station, in the workshop where he attends to the maintenance of all the equipment.





for examination; much information can be gained from a study of the atomic tracks revealed when the plates are developed and examined under a microscope. A party of Bristol University scientists from Prof. Powell's laboratory were also due to visit the Jungfraujoch station this winter.



A Little Sip of Science

MORE than one promising research project has foundered in the same way and for the same reason as certain ill-fated military ventures; that reason can be summed up in the familiar expression "too little and too late". (The Army's other phrase about "sending a boy to do a man's job" is also apposite.)

Too little money for a research scheme means that the research team is too small to tackle a group of problems effectively, and it also means that the scientists are inadequately equipped. There seems to be a certain minimum size—a critical size, so to speak—for the effort entailed before a research project produces results. As a general rule, a team that is too small just cannot mobilise enough intellectual resources and technical skills to solve a given set of problems.

This phenomenon has arisen more than once in the history of Britain's Research Association movement. Indeed one Research Association passed out of existence altogether when the industry—the motor industry—failed to collect sufficient income from member firms to justify the Government, through the D.S.I.R., giving it a grant. (Most Research Associations get a Government grant and this grant is conditional upon the industry that will benefit from the existence of the Research Association collecting a certain minimum sum of money. The Government has long recognised that too small a research enterprise is a waste of time, money and human effort.)

The same problem has arisen again in the printing industry, which has been strongly criticised by the Secretary of the D.S.I.R., Sir Ben Lockspeiser, in the speech he made to the annual luncheon of PATRA—the Printing, Packaging and Allied Trades Research Association. This is what he said:

"We have seen how science has affected industries and yours is no exception. A Research Association such as yours should be able to devote about 10% of its effort towards looking ahead ten years, with freedom to experiment on certain broad lines which the best opinion in industry and science considers likely to pay good dividends in the future. This would mean increased financial support, but the benefits of science are not to be obtained on the cheap and very few of you here today I imagine, would contend that your present contributions are adequate. Your average contributions in both printing and packaging—£34 and £45 respectively—are among the lowest in the whole Research Association movement. The total contribution from the printing industry, with an annual net output of £98,000,000 is only £21,500 per annum. The nation's packaging bill is estimated at £300,000,000 per annum and the packaging industry's contribution to research is only £8500 per annum. These contributions for research are ludicrously small in proportion to the annual product of industry. Some of you will remember Mr. Swiveller asking the small servant in the Old Curiosity Shop whether she had ever tasted beer, and on her replying that she had a sip of it once, exclaimed: 'Here's a state of things! She never *tasted* it—it can't be tasted in a sip!' I can say very much the same thing. You are not likely to taste the benefits of science so long as you only sip at it—and such delicate sips too. I hope your industry will take a good long draught including those who have not yet learned even to sip. The daily press with a few notable exceptions is much better at writing leaders about scientific research than at writing cheques for it, and if only we could bring the level of the latter up to the standard of the former the results, as far as I can judge, would be incalculable. I am not unhopeful that the industry will make financial provision for its Research Association on a scale which is fitting and worthy of the place the industry occupies in our national life."

Unfortunately for the administrators, how much money must be put into industrial research enterprises of this kind cannot be decided by application of a universal set of rules. Indeed, often it can only be settled by the process of trial and error, for what applies to one industry may be quite irrelevant to another.

We have mentioned failures due to inadequate finance. Occasionally, though more rarely, too much money can be spent on a research project. In the Research Association movement this might result if money were raised by a system of compulsory levies. (A firm would then pay some fixed percentage of its turnover, or the levy could be made proportional to, say, the amount of raw material consumed or the quantity or value of the goods produced.) Professor Ronald S. Evans who recently produced an important volume on *Co-operative Industrial Research* (Pitman, London, 1950, 285 pp., 20*s*.) considers this point. A rich Research Association with a guaranteed income such as it would derive from a compulsory levy could give an enhanced sense of security which might lower the tempo of the work of the less energetic members of the staff. Says Professor Evans: "It may make it more difficult to keep some of the members of the staff as aware of and as

keen to serve the interests of their industry as they ought to be. It is true that members (through the Council of the Research Association) control the appointment of the director and, through him, have it in their power to see that the research programme is efficiently prosecuted. Nevertheless quite a sensible lowering of efficiency could take place before sufficient of the members were brought to the stage of doing anything positive about it." Another source of wastage can arise through the diversion of effort to matters of administration which consume much time in large units.

The efficiency of research units in general and Research Associations in particular is much under discussion at the present time. Even the most superficial survey reveals how greatly conditions in this sphere have changed in the past ten years. A decade ago it was simple enough to argue the case for greatly increased expenditure on research in general; there were so many obvious gaps needing to be filled. Today the emphasis of the discussion has changed: the arguments for more research were accepted and the expenditure on all kinds of research has been greatly increased.* Today the people who foot the bills for research want to know what they are getting for their increased expenditure, and they seek indices by which they can gauge the 'efficiency' of the research enterprises which they support. By and large, research continues to prove a good industrial investment, and most industrialists are ready enough to admit that this is so. But there are very good reasons for thinking that the enterprising industrialist is coming to realise that industrial research pays no dividends unless it is properly coupled to industrial development. Even such men as Sir Henry Tizard, who sits on the pinnacle of the Government's scientific pyramid, are urging the application of knowledge rather than the accumulation of more knowledge which may be applied in the future. The words *research* and *development* are now becoming inseparable, and it is the latter word rather than the first which tends to be stressed today. This is reflected in the prevailing demand for such men as chemical engineers and development engineers, and this trend is likely to be maintained for a long time.

Electricity from Tropical Seas

IN the September 1950 issue of DISCOVERY we mentioned briefly a French scheme for the utilisation of temperature differences between tropical sea-water in its surface layers and at a depth.

The scheme, which is now the subject of a full-scale experiment at Abidjan on the Ivory Coast, hinges on the fact that the temperature at which water boils depends on the pressure under which the boiling operation takes place, an everyday example of this phenomenon being the ease with which water is boiled at the top of a mountain, where the atmospheric pressure is lower than at ground level.

The difference in temperature between the water at the surface of the sea in tropical regions and that at a depth of about 2000 feet, has been found to be about 36° F. To extract energy from any warm substance it is necessary to cool it. In this case, the possibilities of cooling are obviously limited by the low range of temperature: but the supply of this 'potential energy' is infinite. One of the main problems is thus to handle the large quantities of water required for a generating plant on a commercial scale. The designer has at his disposal for cooling purposes water at a low temperature which only requires to be pumped from the depths of the ocean. The greatest amount of heat he can obtain from each pound of water is 36 British Thermal Units. (The British Thermal Unit is the amount of heat needed to raise the temperature of 1 lb. of water by 1° F.) To produce one unit of electricity, under conditions of ideal efficiency, 3415 British Thermal Units are needed.

Basically, the method of extracting the energy is to pump warm water into a turbine enclosure, a part of which is completely sealed. An extraction pump produces a condition approaching complete vacuum. The water will then evaporate, and this water vapour passes through a turbine wheel into a condenser, where it meets cold water pumped up from the depth of the sea. This results in immediate condensation and the 'suction' effect (created by condensing the water vapour) causes the rapid passage of vapour through the turbine wheel, and by a reaction effect this wheel then rotates.

A single turbine wheel is used, and in view of the large quantities of water vapour which have to be handled it is of interest to note that the wheel has to be of a diameter of 26 ft. for a power of 5800 kilowatts with a speed of 600 revolutions per minute. (For comparison the turbine wheel of a steam turbine to develop 5800 kilowatts, running at 1500 r.p.m., would be of the order of no more than 3 to 4 ft. in diameter.)

The first power station in the world to utilise this form of energy will have two units of 3500 kilowatts each.

This experimental temperature-difference plant employs pipes running out to the deep sea, and these pipes are carried on floats, and have rubber joints to permit of movement. The pipeline in this particular case is 2½ miles in length.

Among the problems which had to be solved was the design of exhausters to deal with the air and gas trapped in the sea water. It has been found that the extraction apparatus absorbs no more than a fifteenth part of the output of the plant. The other main auxiliaries required are the cold and warm water pumps, and in spite of the fact that 355 cubic feet of water per second is needed for a machine of 7000 kilowatts, involving pipelines of 8 ft. in diameter, the efficiency of the plant is expected to be high, although exact figures have not yet been given.

From another point of view, the plant at present under construction will need slightly less material by way of cement, steel, and the like for a given kilowatt output than is the case for a normal steam power station.

Among the few disadvantages, the obvious one is that stations can only be installed at suitable points on tropical coast-lines, and it is not necessarily the case that electrical energy is likely to be needed at these points. Thus there may be transmission line costs to be taken into account in considering the economics of this new form of energy.

* Thus in the ten years 1937 to 1947 the number of Research Associations increased from 20 to 35; their total income increased from £423,000 to £2,404,000 in that same period.

A Proposal for Atomic Peace

J. BRONOWSKI

At midnight on July 15, 1945, a number of scientists were looking up at the weather in the desert of New Mexico. They were wondering if it would clear in time to have the first atomic bomb exploded at dawn. They were also wondering how many tons of T.N.T. the bomb would turn out to equal; and to pass the time they ran a dollar sweepstake on the answer. Dr. J. R. Oppenheimer, the scientific leader of the development of the bomb, put his dollar on 300 tons of T.N.T.

This story puts in a nutshell the dilemma and the unhappiness of the scientists of our generation. Of course Dr. Oppenheimer knew as well as anyone else at New Mexico that the bomb was expected to equal 20,000 tons of T.N.T. And he knew better than anyone else that neither the bomb nor the forecast was likely to be out by a factor of 70. Dr. Oppenheimer put his dollar on a modest bang of 300 tons not because he believed that the atomic bomb would amount to no more, but because he hoped that it might not.

Scientists in Doubt

Like those troubled men six years ago, we are all wondering whether we have played the Sorcerer's Apprentice. Every scientist today is distracted by the fear that science is over-reaching itself. Whether he works at a fuel or a drug or a gadget, one night at midnight he wakes to ask himself, Is it really going to be a good thing? And if it is, will it come to anything? Is there any science left which does not contribute to destruction? Is there—no, *can* there be any good science?

I have said that this is what scientists ask themselves. The laymen, of course, do not stop to ask; they are sure that they know the answers. Miners and bank clerks, policemen and bishops and members of the Army and Navy Club, they are all united in one belief: that the world is going to hell, and that the men who are taking it there are the scientists.

These fears did not begin on July 16, 1945, and their cause lies deeper than the atomic bomb. The nations that have gained so much from science have come to doubt their own purpose. Science and the big bombs are only the scapegoats, on which our civilisation blames its own loss of nerve.

For let us be clear about this: our civilisation has made its riches with its own hands, by the use of science; and to cast doubts now on that tool is a counsel of despair. In the three hundred years since the birth of Newton we have doubled the span of life. We have cut back the infant death rate to one-third even in the last fifty years. We have enormously enlarged our effective life in health and well-being and education. No one in his senses can think that these achievements are dwarfed by the threat of the hydrogen bomb.

No, the bomb is merely the symbol for the layman's fear of something larger: not the threat to his life but to his way of life. The bomb has made vivid and actual to him what he has long known and tried to hide—that the world is running away with him. Its issues now are too large, he feels, its decisions too searching; every argument, from a penny on the rates to the size of the Air Force, is dominated by technical issues which he dare not judge. The layman blames science, not because he feels afraid, but because he feels helpless.

We should not let the layman go blameless for these sad and bitter feelings. But our task, the scientists' task, is not to blame or to reprove; our task is to cure. What are we going to do as scientists to set these doubts at rest, to head off the sick search for scapegoats, and to give confidence again to people to whom the comic strip has become a refuge from the news from China?

The Promotion of Confidence

We shall not give the world this confidence unless as scientists we have confidence in ourselves. The laymen do not lack a sense of right and wrong—not even the politicians and the career diplomats. But they do lack any sense of the scale of scientific movement, its speed and its fullness. They cannot weigh 30 years of life-span against a bomb; they do not understand the choice between such uses and such achievements.

And can we scientists then make the choice for the community? Of course not. But we can do something more important—we can make the choice plain. This is now the crux of our task; to see ourselves again as educators and to see science as a work of enlightenment, to teach bewildered men what is possible and what is at stake in the world today.

The imagination of the world has been set on fire by the discovery of atomic energy. We fail in our own gifts as scientists if we acquiesce in the layman's fear that nothing but harm can come of the discovery. More than this, we fail as scientists so long as we allow ourselves to be dominated by the stock judgment that atomic energy is above everything a threat—the threat of war. Can any man of sense, layman or scientist, really be so simple that he thinks himself afraid of war because of the atomic bomb? We are not afraid of war because there are now atomic bombs; we are afraid of atomic energy because we are not sure that we can keep off war.

We surely must stop bandying these reach-me-down opinions, on both sides—those who clamour to use the bomb, and those who clamour to forbid its use. It is really too late, by quite a hundred years, to have a man with a flag walking by law in front of every atomic bomb. And equally, it is time that we put aside the penny-wise calculations which the Public Relations Officers of power companies run up on an old envelope. No doubt six-sevenths of the cost of electricity now goes to pay for its distribution and not for the fuel. No doubt we cannot use a very hot pile until we find something better than aluminium to sheathe the uranium slugs. No doubt we have still to solve major problems before we can make the fissile materials in a pile self-breeding.

No doubt, in short, there are technical problems to solve by the hundred; but does anyone doubt that the great scientific discovery has been made, and made triumphantly? Atomic energy is here to stay and, if we want to stay with it, we had better acknowledge it for what it is—a power which will remake the future, willy-nilly, and which we shall command only so long as we are as bold and imaginative as that future.

What then as scientists should we believe, and what should we do? We must believe in ourselves, we must believe in the good in our work. And we must act for the fulfilment of that good. The world has been set on fire by the discovery of atomic energy. And the world waits for a sign from us. Do we believe it to be good? Of course we do; there is no discovery of the last three hundred years, from bacteria to dynamite, which has not done immensely more good than harm.

An Objective for the United Nations

Why should we wait for the good—for three centuries or three decades? There is no reason in the world. We know that atomic energy can be used for good; we and no one else. If we want to lift the doubt from others, it is we who must speak out. We, the scientists, must go to the United Nations and say: The world is full of deserts, the Sahara, the Gobi, the deserts of Arabia and Patagonia, Iceland and Australia and New Mexico itself. The population of the world is growing at the rate of 1% each year; and the food supply is not. Let us make at least one strip of desert fertile and habitable. To do this we shall need power on a massive scale, to pump water, to set up industries, to unfold a new life. And for that power, let us use the gift which a whole world knows and distrusts. There are other ways of running power stations in the desert: but this is the way the world is waiting for. Let us build at least one United Nations power station and give to the waiting world a task and a hope in which at last it can take pride again.

I am aware that each of the large nations would find six excellent (and quite different) reasons against this plan. But the time for being impressed by their political acumen, on both sides, is past. Five years have now been spent at Lake Success in arguing how *not* to use atomic energy; and no progress has been made except that everyone is busy voting money to use it—in war. One positive plan for action by the United Nations Atomic Energy Commission today is worth years of negotiation and limitation of arms. And if the political bigwigs wag their heads, let us get the small nations to take the initiative. The small nations have no interest in atomic energy for war; and they have the most urgent interest in its real use for peace.

For this is a plan, and perhaps the only plan, in which the small nations can take their share. There are 50-odd members of the United Nations; a modest and equal contribution from each of £1 million would pay for one major desert power station and the scheme of irrigation to go with it.

So we need have no qualms as to whether this is a practical scheme. It is as practical as the British Plan for Coal or any of the Russian Five-Year Plans. There are technical and political difficulties to overcome. But how long it takes to overcome them rests only with us, the scientists. If we have not the courage to meet them now, in peace time, then they will be met by another generation of scientists one peace later. We shall only have missed the opportunity—and the chance to survive until then.

For of course the desert stations will come, if not in the 1950's, then in the 2000's. The challenge to us is whether we have the imagination to advance them by fifty anxious and warring years. For our own sakes, as scientists and as men, we must press for a large, practical, international scheme which will use atomic energy actively and peacefully. We can begin the plans this year, and we can be building in three or four years from now.

A Faith for Scientists

In the years since the war, the doubts and the fears of a whole civilisation have turned against science. And, more gravely, the scientists have come to doubt themselves, and to ask whether their work is more than a blind and purposeless exploration which must be judged by the traditional values—by Plato and Buddha and Christ. We are in danger of seeing the scientific method and the scientific mind reduced to the status of drudges in another Dark Age of faith without works. The thinking scientist should not be browbeaten by these devices. For thousands of years now, the values of the world have been fed by famine: their spring has been the ancient ascetic belief that the basis of all values is denial. The values of science are real and human, and they are in flat contradiction to these, for they rest on the principle that the basis of value is fulfilment. This is the conflict of our age, and we must not retreat from it as the doubters are doing. As scientists, we must prove that we believe in human fulfilment, and that we have something to give towards it. This is why I have no patience with talk about limiting this and forbidding that, and all the famine mentality of the tired administrator in committee. Science is a giving, material and spiritual; on that all its values rest. Let us as scientists act out that belief, and treat atomic energy for what it is, a great gift which is in our hands.

At dawn on July 16, 1945, the allied nations had spent 2000 million dollars to prove that atomic energy would work. At the present population of the world, that works out at a dollar a head. It is time that we gave the citizens of the world their dollar's worth. This is a simple picture, but I like to think of it in this way: that a United Nations Project for the Peaceful Use of Atomic Energy in the deserts of the world is the debt we owe to every human being of his dollar's worth of the future. It seems to me Dr. Oppenheimer's best bet if he means to get his dollar back.

FIG. 1.—Reconstruction of the first inoculation of a G.P.I. with malaria by Professor Wagner von Jauregg in his clinic in Vienna. Professor Jauregg is seen to the right of the 'patient', who is being infected by scarification.

Twenty-five Years of Malaria Therapy

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UNTIL the introduction of malaria treatment in 1917, a diagnosis of General Paralysis of the Insane (G.P.I.), a disease of the central nervous system caused by the attack of the syphilis germ, was tantamount to signing a death certificate, because at that time there was no known cure for this disease and a spontaneous recovery seldom, if ever, occurred.

Although as far back as 1887 Professor Wagner von Jauregg, a Viennese psychiatrist, published a paper advocating fever in the treatment of patients suffering from G.P.I., it was not until 1917 that he first used malaria with the aim of curing this disease. By 1927, when he was awarded the Nobel Prize for his pioneer work in this field of medicine, every country in the world accepted induced malaria fever as the only worthwhile treatment of G.P.I.

In spite of numerous investigations, the exact mode of action of induced malaria in this form of therapy remains unexplained, although a number of theories have been advanced. We know that the spirochaete causing the disease is killed at temperatures between 110° F. and 114° F., but the growth of the spirochaete is halted by temperatures much lower than these. If, however, temperature alone killed the infective organism then there would be no apparent reason why means other than malaria would not be equally effective. High temperatures can be produced in many ways, such as injections of milk causing 'protein shock', injections of anti-typhoid vaccine and also by diathermy. (Diathermy is a process by which electric currents can be passed into deeper parts of the body and produce high temperatures). All these methods have been tried extensively for the treatment of G.P.I. with some success, but none is as good or as permanent as treatment by malaria. Some workers believe that in addition to the fever produced by malaria there is a biological antagonism between the malaria parasite and the spirochaete of syphilis.

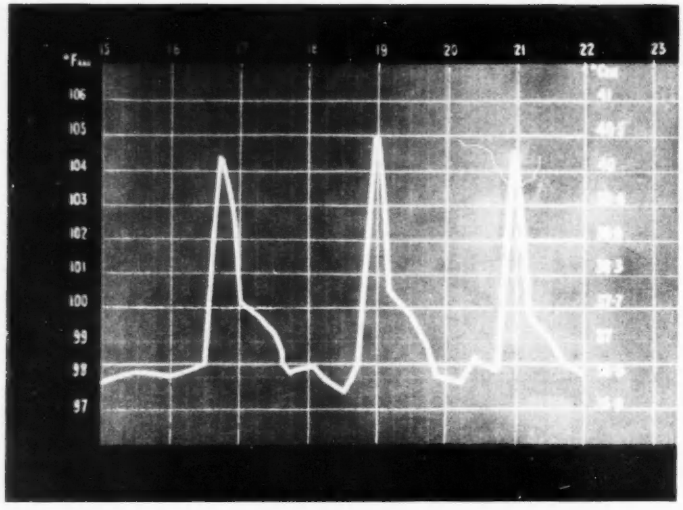

FIG. 2.—The temperature chart of a malaria patient. Note the fever peaks, recurring every other day. A full course of malaria therapy involves at least ten bouts of fever.

Method of Inoculation

There are two methods of inducing malaria, one by the bites of infected *Anopheles* mosquitoes and the other by the injection of blood from a patient suffering from malaria. Wagner von Jauregg's pioneer work was done by using blood inoculations. It was not until 1922 that patients were infected by the bites of mosquitoes, when this method of treatment was started in England by the late Professor Warrington Yorke of the Liverpool School of Tropical Medicine. In 1923, the Ministry of Health decided to establish a central malaria laboratory where special strains and species of malaria parasites could be cultured in both man and mosquito.

It was realised that if malaria-therapy was to be used in hospitals all over the country it would have to be put on a sound scientific foundation. It was not sufficient to find a patient suffering from malaria and to take some of his blood and inject it into a patient awaiting malaria treatment.

There are at least four species of parasites which cause malaria in man. One species (*Plasmodium falciparum*) is extremely virulent and would, if not treated by antimalarial drugs within a few days of the outset of fever, produce a very high death rate. Another species (*P. ovale*) is so very mild that after five or six bouts of fever there is usually a spontaneous recovery. Another species (*P. malariae*) is rather mild and has a prolonged incubation period. The fourth species (*P. vivax*) is relatively safe and yet produces high temperatures, either daily or every other day, but is easily controlled by antimalarial drugs. (Temperatures of 107° F. have been recorded on several occasions without causing undue anxiety.) In addition to the differences between *species* there is also the problem of *strains*, for there are numerous strains within a species and each appears to have certain characteristics, such as susceptibility to drugs—one strain in Europe was found to be eight times as resistant to quinine as a different strain of the same species from Africa.

It is of interest to record that Professor Wagner von Jauregg informed the writer in his clinic in Vienna that he considered himself fortunate in that he used the species *P. vivax* for the treatment of his first cases; had he used the species *P. falciparum* a number of his patients might have died and the future of malaria therapy would have been seriously jeopardised. It was with great pleasure that he responded to my request for a photograph of a reconstruction of the scene of the first case he infected with malaria in the actual room at his clinic in Vienna where the inoculation was carried out. It will be noted from this photograph that the drop of malarial blood of the donor was dropped on the skin of the arm of the recipient and was then scarified as is done in smallpox vaccination; he informed me that he was afraid to inject blood in case it produced too severe a fever.

The importance of using the right species and strain was, naturally, recognised by malariologists more readily than by psychiatrists. When, therefore, it was decided that the Ministry of Health should make itself responsible for the distribution of malaria material to hospitals all over the country, a great deal of experimental research became necessary. This was started in 1923. It was decided that, in addition to infecting patients by direct blood inoculation, infection should also be produced by the more natural method of letting infected mosquitoes bite the patients.

To obtain a suitable species and strain of parasite we arranged with the Chief Medical Officer of the Port of London to inform us when ships arrived with active cases of malaria among the crews. When word was received of suspected cases of malaria among crews on ships, the ships were visited and blood films were examined for malaria parasites. This search continued until cases with parasites of *P. vivax* were found. (This species is generally referred to as 'benign tertian', as it produces fever, which is not severe, every three days.) When a case of benign tertian malaria was discovered, a few cubic centimetres of blood were taken from the patient and sent to a mental hospital where cases of G.P.I. were awaiting malaria-therapy. In this way numerous patients were infected between 1922 and 1925 with strains of benign tertian malaria parasites originating from India and Africa.

The object of testing several strains of a species of parasite was to obtain one which would fulfil all the requirements of the psychiatrist and also of the malariologist. It was recognised that the chief requirements were:

1. The strain must produce temperatures of 104° F. to 106° F. with minimum risk to the life of the patient.
2. It must respond quickly to quinine treatment so that the fever could be stopped if necessary. (At that time quinine was the only drug of proved value against malaria).
3. The strain must produce large numbers of gametocytes (sexual forms of the parasite) so that mosquitoes

would become infected after sucking the blood of the patient.

4. The sexual parasites must be able to develop in the tissues of a particular species of *English* mosquito which, it had been decided, should be used for this work.

When, therefore, the patients infected with foreign strains of malaria parasites developed fever, temperatures were recorded every fifteen minutes during the whole of an attack which usually lasted for about eight hours. Each patient averaged ten to twelve attacks over a period of ten to twenty days. When sexual forms of the parasites appeared in the blood, as determined by microscopic examination, hungry mosquitoes were allowed to feed on the patient to determine whether the parasite was able to complete its cycle in this particular insect. Where success was obtained, these mosquitoes were allowed to bite other patients and in these too, the severity of the fever and other requirements was carefully watched. This concentrated and detailed work continued for over two years. Many strains of parasite were rejected because they failed to fulfil all the requirements stated above. In 1925 a strain of parasite was tried which was obtained from a Lascar recently returned from Madagascar. It fulfilled all the conditions necessary. In May 1925 this strain of parasite was taken to Horton Hospital, Epsom, where it had been decided to establish a special malaria unit. Special insectariums were built where mosquitoes could be bred and infected; the wards were rearranged so that they could be effectively mosquito proofed (to prevent 'wild' mosquitoes getting in and perhaps becoming infected by biting the active cases of malaria and also to prevent infected mosquitoes getting out in case of an accident). This strain has been used in most hospitals throughout Great Britain, America and most countries of Europe.

At Horton Hospital, hundreds of thousands of mosquitoes have been infected and thousands of patients treated. The writer has been actively engaged in this work since its inception twenty-five years ago, including the initial selection of the strain of parasite from among ships crews and the setting up of similar malaria units in other parts of the world.

Because of obvious risks, mosquitoes are never sent through the post or even by other impersonal forms of transport. The insects, in batches of about twenty, are moved in small museum jars which are covered at one end with a double piece of mosquito netting with a mesh too small to allow the mosquito to escape but large enough to enable the insect to extend the proboscis and suck blood from the patient. A Ministry of Health official personally conveys the jar to the hospital and infects the patient. Although the risk of English mosquitoes feeding on patients suffering from malaria in hospitals is small, it is nevertheless present, especially in hospitals situated in rural districts. As a precautionary measure it is compulsory that all patients undergoing malaria-therapy between the months of May and September (the season when mosquitoes are active in these islands) must occupy beds which are mosquito-proofed.

It has been found that the parasite of malaria is able to survive in drawn blood for days or weeks providing the blood is kept near freezing-point. Therefore when requests are received from hospitals too numerous or too far distant to be visited, a few cubic centimetres of blood from an active case of malaria are taken, defibrinated (to prevent clotting), packed in a Thermos flask full of ice and sent to the hospital by the speediest means of transport available. On arrival at the hospital the tube of blood is raised to body temperature and injected into the patient. Fever usually begins between ten and fourteen days later.

The preparation of infected batches of mosquitoes involves detailed technique because many important factors have to be taken into consideration. Mosquitoes, like most insects, are highly susceptible to temperature and humidity. Therefore the first consideration was the establishment of a large colony of mosquitoes which would breed and thrive under laboratory conditions and which would feed readily on man and acquire malarial infection. For several years adult mosquitoes were collected from pigsties, horse-stables and cowsheds where they were known to occur in large numbers and brought to the laboratory and kept at a suitable temperature (75° F. to 80° F.) to hasten digestion of the existing animal blood.

When a batch of infected mosquitoes is required, a patient with active malaria is selected on whom to feed the mosquitoes. It should be remembered that the stage of parasite which produces fever in man is a non-sexual phase and cannot infect mosquitoes. After a patient has had these non-sexual organisms in his blood for a few days, some of them change and take on sexual characters. These sexual parasites are quite distinguishable microscopically and so before a batch of mosquitoes is fed on a patient, the blood is examined and the number of sexual forms per cubic centimetre is estimated. If the count is satisfactory,

FIG. 3.—Sporozoites of the malarial organism escaping from the salivary gland of a mosquito.

several museum jars, each containing 30 or 40 hungry mosquitoes, are held against the leg or arm of the patient for about an hour. At the end of this time most, but not all, of the mosquitoes will have fed. These are then taken to the heated laboratory where each mosquito is examined for the presence of blood in the stomach, proof that the insect has had an infective feed. Usually a batch consists of about 300 mosquitoes and it is fortunate that only in exceptional cases is there any irritation. The fed mosquitoes are then transferred to a large mosquito-proofed cage 2 ft. square and each night a rabbit is put into the cage to provide the mosquitoes with further blood meals. About ten days elapse between the time a mosquito takes an infected blood meal and until it becomes capable of transmitting the infection. During this period some mosquitoes are dissected daily to observe the severity of the infection and also the development of the parasites. For the first eight days the mid-gut only is dissected, and a microscopic search made for the cysts which are to be found on the gut-wall. On the ninth day of infection most of the cysts will have reached maturity, when they rupture and organisms (sporozoites) which have developed inside the cysts are released into the circulation of the mosquito; most of them reach and penetrate the cells of the salivary glands. At this stage the mosquitoes have passed from being infected to becoming *infective* (able to transmit the infection by their bites). Each cyst manufactures about 1000 sporozoites and as in heavily infected mosquitoes as many as 1000 cysts may be found on a single stomach, a single mosquito may harbour as many as a million organisms, each capable of causing malaria, without any apparent harm to the insect host. When the salivary glands of the mosquito are invaded by the parasite, they are ready for transmitting the disease to other patients awaiting malaria-therapy. The technique of breeding mosquitoes, infecting them with malaria and in turn inducing malarial fever by their bites is now a routine procedure which has continued uninterruptedly for twenty-five years.

In the early years, adult mosquitoes were collected as and when required from areas where they were known to be plentiful, particularly in the low-lying areas of Kent and Essex, but the colony of mosquitoes, started at Horton in 1933 from the eggs of a single specimen, continues to breed vigorously, and there have been many thousands of generations. As this species of mosquito is neither completely anthropophilic (feeding only on man), nor completely zoophilic (feeding only on animals other than man), it is a very useful and convenient insect to work with. In the insectarium where the mosquitoes are bred and where large stocks accumulate, a small pig is housed and provides blood meals for hungry mosquitoes throughout the day and night. The strain of parasite, introduced as the parasite of choice in 1925, has shown no morphological changes and no changes in virulence over the whole period.

The introduction of malaria-therapy has led to significant additions to our knowledge of malaria which, it is estimated, afflicts at least one-third of the human race, with an annual death rate of several millions. Further, the large-scale use of mosquitoes for inducing the disease has provided opportunities for studying the life history of these insects and searching for the weakest link in the chain of their life cycle; the knowledge gained may be applied for their destruction in nature.

Malaria-therapy has contributed greatly to our knowledge of useful synthetic drugs in the treatment and prevention of malaria. A technique has been devised where a known number of infective organisms (sporozoites) can be injected into patients awaiting treatment—in one case fifteen million germs were injected. This enables workers to estimate with some degree of accuracy the value of new drugs.

Fortunately for society, general paralysis seems to be getting less frequent. Perhaps the time may come when malaria-therapy will be discontinued or be superseded by some other form of treatment. Even should this happen, malaria, which has destroyed civilisations, killed millions of people and indirectly caused the deaths of millions by starvation, will, even to a small extent, have done something to redeem its evil reputation as the 'King of Death' between the years 1917 and some future date.

Sir Ronald Ross, who in 1897 discovered the part played by the mosquito in the transmission of malaria, wrote the following lines:

I know this little thing
A million men will save.
O Death, where is thy sting,
Thy victory, O grave.

Many lives have been saved by the intervention of malaria-therapy, and these lines have proved even more prophetic than Ross could possibly have imagined when he wrote them fifty-three years ago.

THE RUTHERFORD MEMORIAL FUND

TARGET figure for the Rutherford Memorial Fund is £100,000, and by the end of January £60,000 had already been subscribed.

Biggest subscribers were as follows: Steel Industry through British Iron & Steel Research Association, £10,000; Anglo-Iranian Oil Company, £5,000; Associated Electrical Industries Ltd,. £5,000; British Rayon & Synthetic Fibres Producers, £5,000; I.C.I. Ltd., £5,000; Shell Petroleum Company Ltd, £5,000; General Electric Company, £2,500; English Electric Company, £2,000; Brush Electrical Engineering Company Ltd., £1,750; Distillers Company Ltd., £1,500; E.M.I. Ltd., £962 10*s*.

Other major subscribers so far include Albright & Wilson Ltd. (£700), Rolls Royce Ltd. (£700), Standard Telephones (£700), Tootal Broadhurst Lee Co. Ltd. (£700). Dunlop Rubber Co. Ltd. (£525); Babcock & Wilcox Ltd. (£500); Boots Pure Drug Co. Ltd. (£500); British Electricity Authority (£500); Electric Construction Co. Ltd. (£500); May & Baker Ltd. (£500); Tube Investments Ltd. (£500).

The masters and pupils on the Science side of Gresham's School, Holt, have sent 27*s*. 6*d*., and have received a special letter of acknowledgment from the Royal Society for it.

No money has so far been received from abroad. Target figures for the Commonwealth are as follows: Australia, £10,000; Canada, $100,000; India, 100,000 rupees. Contributions should be sent to the Rutherford Memorial Committee, The Royal Society, Burlington House, London, W.1.

Antibiotics and Plant Protection

SINCE 1929 when Sir Alexander Fleming published his classical paper on the antagonistic action of the blue mould, *Penicillium notatum*, on a human pathogen a great volume of knowledge on antibiotics has accumulated. Most of it refers to the medical aspect of these new substances, and very little work has been done on the effect of antibiotics on organisms causing plant diseases.

Penicillin was one of the first antibiotics to be tested against plant pathogens. The majority of bacteria responsible for plant diseases belong to the group called gram-negative (gram-positive means that the micro-organisms retain a certain dye when specially treated). The action of penicillin is, however, directed mainly against gram-positive bacteria. There are a few exceptions, such as the gram-negative *Agrobacterium tumefaciens* causing crown gall, a disease of apples, roses and other plants. American workers have reported successful control of this disease by applying cotton wool pads soaked in a dilute solution of crude penicillin to the aerial galls or by immersing the lower parts of the bushes or young trees in a tank containing the penicillin. This is one of the rare instances of an antibiotic being used to control a plant pathogen in the field. Streptomycin gave still better results for the treatment of crown gall. Many plant pathogenic bacteria are affected by streptomycin owing to its activity against gram-negative bacteria. Examples are *Pseudomonas lachrymans* (the cause of angular leaf spot of the cucumber), *Xanthomonas phaseoli* (responsible for bean blight) and *Xanthomonas pruni*. *Xanthomonas pruni* is the causative agent of bacterial spot on plums and peaches. It has been reported that soaking bud wood in a dilute streptomycin solution keeps the disease in check. Since streptomycin is most abundant in the United States much of the research work carried out with this antibiotic has been on diseases prevalent in America. Two plant pathogens which are cosmopolitan, namely, *Bacterium carotovorum* causing the familiar soft rot of almost all root vegetables and *Streptomyces scabies* responsible for common scab of potatoes, have been shown to be sensitive to streptomycin.

The toxicity of many antibiotics, among them streptomycin, not only to such primitive plants as bacteria but also to the higher green plants is one of the factors limiting the exploitation of these new materials for plant protection. Because the seed is more resistant to poisons than are the green parts of the plant, several antibiotics have given promising results as seed dressings. Streptomycin has been successfully tested as a seed dressing of tomato seeds infected with the organism causing bacterial canker, *Corynebacterium*.

In recent years systematic investigations have begun into the possibility of isolating micro-organisms from the soil which would yield antibiotics active specifically against plant parasites. The green mould *Trichoderma* produces two antifungal substances, gliotoxin and viridin, which are toxic to damping off* fungi such as *Rhizoctonia*, and other organisms such as the fungus *Botrytis allii* which causes neck rot of onion. Unfortunately both substances retain their toxic action only at a degree of acidity which is so high as to upset plant growth. Yet American reports back in the 'thirties claimed that citrus seedlings growing in soil infected with the damping off organism *Rhizoctonia* were protected from the attack of the disease by the presence in this soil of the antagonistic *Trichoderma*.

Gladiolic acid is another of these recently isolated substances which under laboratory conditions inhibits the growth of a number of plant parasites. Examples of fungi sensitive to gladiolic acid are *Botrytis allii*, *Verticillium albo-atrum* which is responsible for one of the wilt diseases of the tomato (sleepy disease), two species of *Fusarium* (which respectively cause dry rot of potatoes and blight of seedling cereals) and *Penicillium expansum*, a common pest on stored apples. However, as with gliotoxin and viridin, this fungistatic action is only retained at a high degree of acidity, and until it becomes possible to circumvent this dependence of fungistatic action on high acidity there will be little scope for these materials for plant protection. Expansine is an antibiotic which gave very good results under laboratory conditions against bacteria causing soft rot and against *Phytophthora parasitica* and a species of *Pythium* which cause 'damping off' disease among seedlings. It is stable at low acidity, but it is very injurious to plants. It has been tested as a seed dressing but though very promising under experimental conditions it has failed to give satisfactory results in field trials. When used as a soil disinfectant, expansine has occasionally yielded good results against damping off when applied sometime before seed sowing. On the whole far too little work has been carried out with this antibiotic under field conditions to justify a final judgment as to whether or not it will have some practical value.

Apart from those antibiotics which have been isolated and purified there are many which have been tested in their crude state as present in culture filtrates of a great many micro-organisms, especially actinomycetes. These filtrates when added to infected soils have under certain conditions protected plants growing in these soils from disease attack.

This branch of research is still in its infancy and some time may elapse before sufficient data will be available to make it possible to use antibiotics as sprays, dusts or as seed and soil disinfectants. The difficulties to overcome are still great owing to the instability of some antibiotics, their injurious effects on plants, and their inevitably high cost of production.

Antibiotics may play a part in a different mode of disease control, namely biological control, exemplified by the use of the fungus *Trichoderma* in America already mentioned. The majority of organisms which produce antibiotics live normally in the soil. It is in the soil that many plant parasites occur. Therefore investigations have been made into the possibility of inducing the formation of antibiotic substances directly in the soil, thus attacking the parasites at their very origin. It is, however, still too early to draw conclusions from the results obtained in this line of work.

* Damping off is a serious disease of seedlings which causes them to fall over at soil level soon after emerging. The plants rapidly die.

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Ludwig Koch: Master Recorder

C. L. BOLTZ

It falls to the lot of few men to carve a special niche out of this cold grey world and then proceed to occupy it; to achieve this more than once in a lifetime is even more rare. One who has done it is Ludwig Koch, whose recordings of bird songs and animal sounds have become familiar to us *via* the B.B.C., with which his three-year contract as a full-time official has recently ended.

The number of his careers up to now can be reduced to four by lumping some of his activities together. He started off as a child prodigy, a violinist who studied under the most famous teacher of the time. He knew Joachim and is still a close friend of Kreisler's. He can just remember when, as a child of three, his hand was shaken by Liszt. At the age of twenty-four, after his time at the university, he started a new career as a *lieder* singer (he is a bass-baritone), one of his teachers being Jean de Reszke. This career ended abruptly in 1914 with the outbreak of war. Ludwig Koch served in the German Army.

To clear up any misunderstanding it should be said at once that he is now a naturalised Briton. He was born in 1881 at Frankfurt, the son of a German father—a botanist at the Senckenberg natural-history museum—and a French mother, and he was domiciled in Germany until 1936, when he became a voluntary exile from Hitler. This was not the result of racial persecution, for Ludwig Koch is not a Jew. He had been, it is true, arrested and interrogated four times because, as a Social Democrat and a courageous individualist, he was outspoken in his criticism. But this was hardly persecution in the extreme sense—despite his lack of height he towered threateningly over seated black-shirts when they tried to bully him—and highly placed Nazis wanted him to stay. He left because he hated everything that Hitler stood for. It is worth recording in the lesser annals of fame that Ludwig Koch left Germany for ever on a return air ticket supplied by Goering.

In 1918 Ludwig Koch started on his third career as a public administrator. He organised the repatriation of Allied prisoners of war, served as liaison official with the French troops of occupation, and was afterwards a public official of Frankfurt in charge of publicity and exhibitions. It was in this capacity that he organised in 1927 what his friend Edouard Herriot called 'The League of Nations of Music', but known officially as 'Music in the Life of Nations'.

A year later he started his fourth career, though 'started' is misleading, for it had been running through his whole life. At the age of eight he was given by his father a small Edison-type home recording outfit. With this he recorded the song of a pet bird. His passion for this new scientific device led him to substitute it for an autograph album, and instead of asking for signatures and verses he asked for voices and performances. This novelty found favour with the great. He recorded the voice of Helmholtz; he recorded the thin squeaky voice of the giant Bismarck.

This same passion drove him to continue his work of recording bird songs on every possible occasion. So when he became director of the culture department of the German branches of H.M.V. in 1928, he was not starting but continuing with financial support his fourth career. (During it he recorded a Hildebrandt organ of 1792 at Sturmthal near Leipzig, an organ played originally by Bach; this record is unique, there is no other.)

Within a short time of his arrival in England in 1936 he was approached by the B.B.C. Many men gave him active support—not in money, for he is proud and independent—for at the age of fifty-four he was an exile without possessions and only his skills for his support. One provided him with an office and placed recording equipment at his disposal. Julian Huxley wrote a foreword to his first book of bird song, published, with records, by Witherby's of Holborn. The most surprising name among all those who gave support is that of Neville Chamberlain, who is seen in quite a new guise—that of amateur naturalist and bird lover. It was to Chamberlain that Koch applied for help to realise a dream that had nearly come to reality in Germany. This dream may well establish his fifth career.

Since that time he has never looked back, whether as a free-lance recorder and lecturer, or as a member of the B.B.C. staff. He possesses recordings of the songs of some two hundred different species of birds, as well as a smaller number of mammal sounds. It was Koch who established the fact that the giraffe is not mute but utters an aggressive barking sound under stress of great excitement, and he has recorded the okapi's call, previously never heard by anyone at all. Quite recently he has recorded the rabbit's mating call and the doe's maternal cries. He has established the fact that there are great individual variations in bird performances, there being, as he once said, 'prima donnas' among them. There are also regional variations, a fact that provides a means of studying local migration. For instance, Dr. Koch—he has a Ph.D. of Königsberg—when in Kew Gardens heard a chaffinch and immediately recognised that the bird came from Belgium. He is, of course, besides being the first in the world to record bird song, the world's authority on the song of the chaffinch. It took him years to get his first satisfactory recording of this bird and he insists that this type of work is not so much science as art—he uses quite ordinary equipment, a moving-coil microphone and a standard disc recorder—and that it needs a long apprenticeship. And anyone who has read some of his own accounts may well add the need for patience, a Job-like inhuman patience. The contribution he has made to ornithology is considerable, though still unrealised by many scientists, for the time-intervals of repeated calls have been accurately measured, the acoustic frequencies analysed, and changes of song in the breeding season noted, and all given a permanent record.

It is with this permanence that Dr. Koch's continued dream is concerned. He wants to establish what in German he calls a *Lautinstitut*, more clearly rendered in English as an 'Institute of Recorded Sound'. In 1932 he almost succeeded, for the Prussian minister of culture appointed Ludwig Koch director of such an institute to be housed in Berlin and associated with the university. But Hitler came to power in the following year. In Britain before 1939, Neville Chamberlain gave support but said

that money would have to be provided from private sources. All Ludwig Koch's efforts to get such financial support failed. Now he is hoping again that someone will find the money.

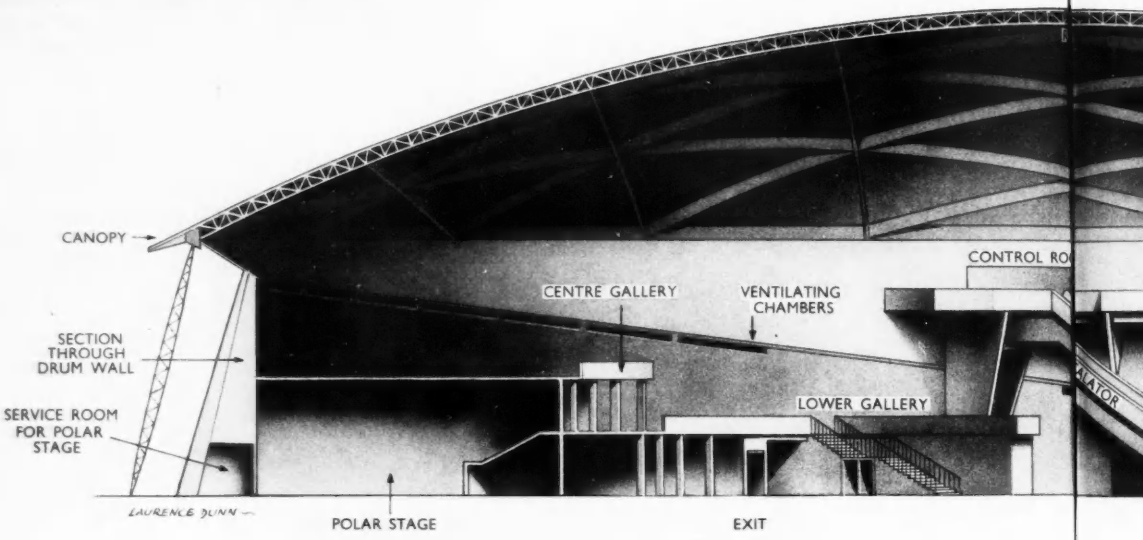
Such an institute would have a library of recordings and a listening-in system available for students singly or in groups, who could come again and again to study special sounds, chiefly those of nature. An ancillary activity might be the sale of records. There is no such institute in the world. It would be invaluable for research and as a historical record. So Ludwig Koch, now in his seventieth year, though looking nearly twenty years younger, may yet start his fifth career. Let us hope that it will start here in England. For then he would stay with us, and the man in the little black beret, the man of charm and sensibility, of courage and integrity, this unique individual to whom there can be no successor, would still be a familiar figure wherever serious naturalists gather together.

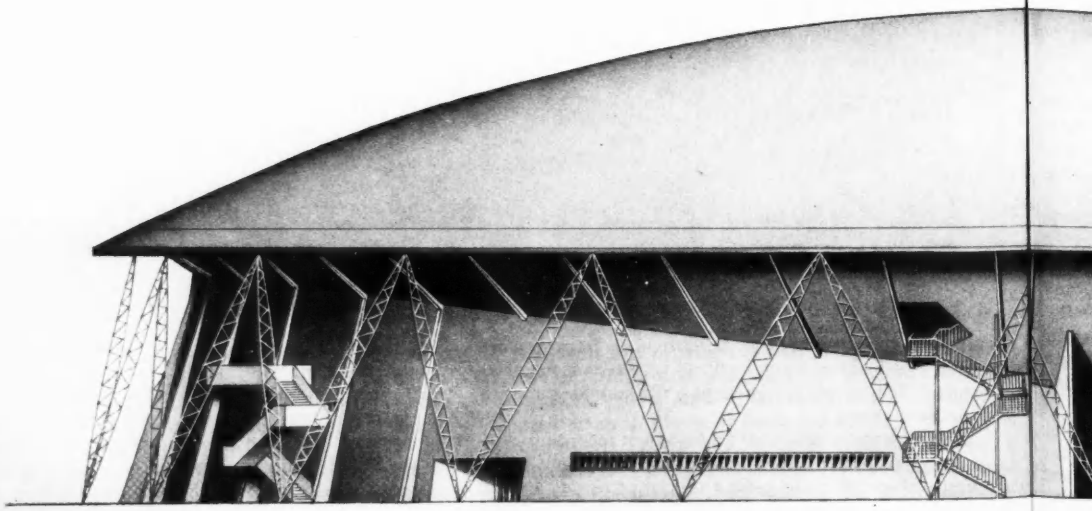
The Dome

Focus of scientific interest in the Festival of Britain will be the Dome of Discovery, which will be the centre not only of scientific interest but also architectural interest. Designed by a young British architect, Ralph Tubbs, this building is quite unique. Its aluminium dome is the largest thing of its kind in the whole world—it has a diameter of 365 feet and there will be 93 feet between the apex of the dome and the ground. These drawings by Laurence Dunn show the main features of its construction.

At the moment this edifice is the outstanding building on the Festival site, its metal roof shining conspicuously in the sun. The whole thing looks like a vast silver igloo.

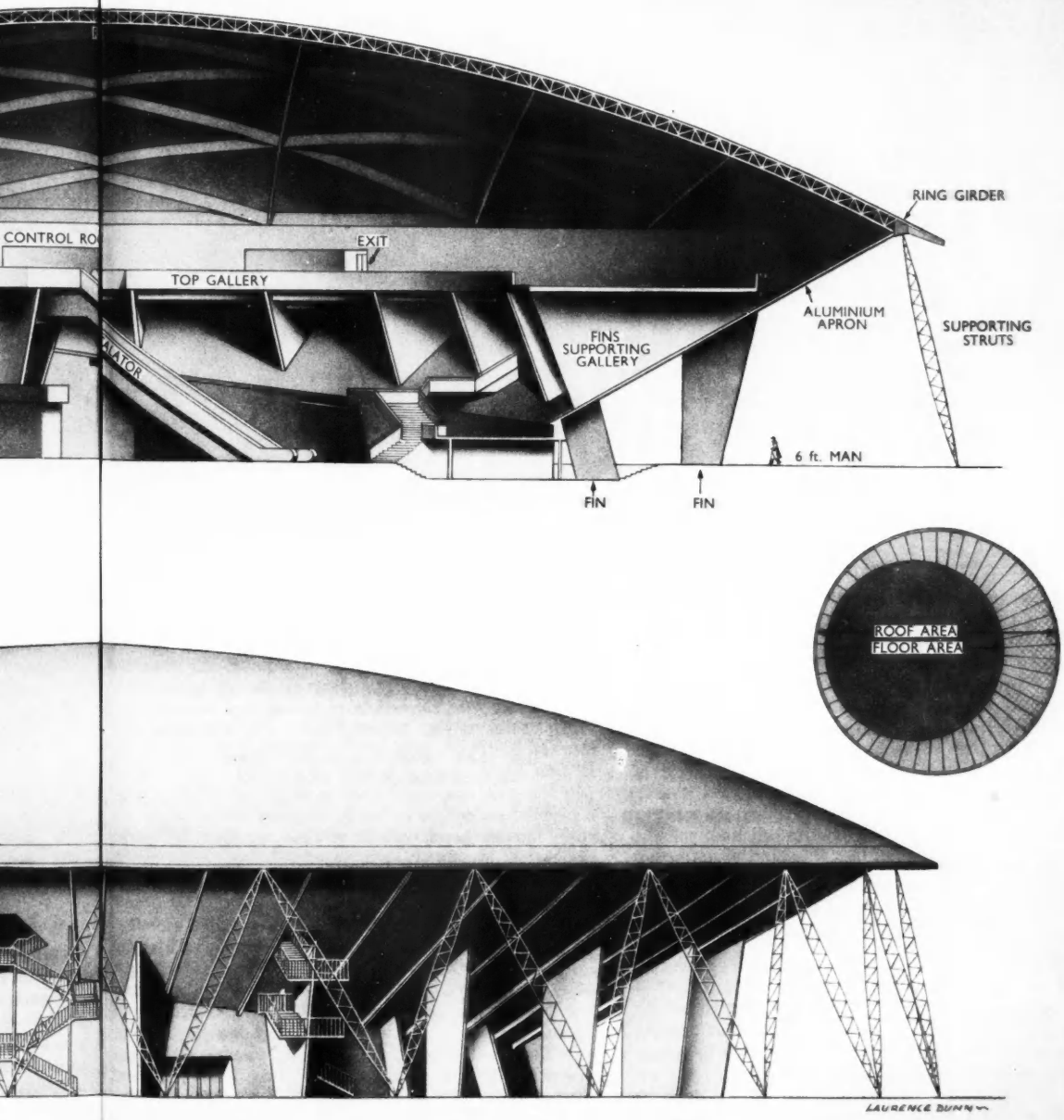
The story to be told in the Dome of Discovery is British pre-eminence in discovery and exploration not only by land and sea but into the very nature of the living world and the universe. Thus, ranged



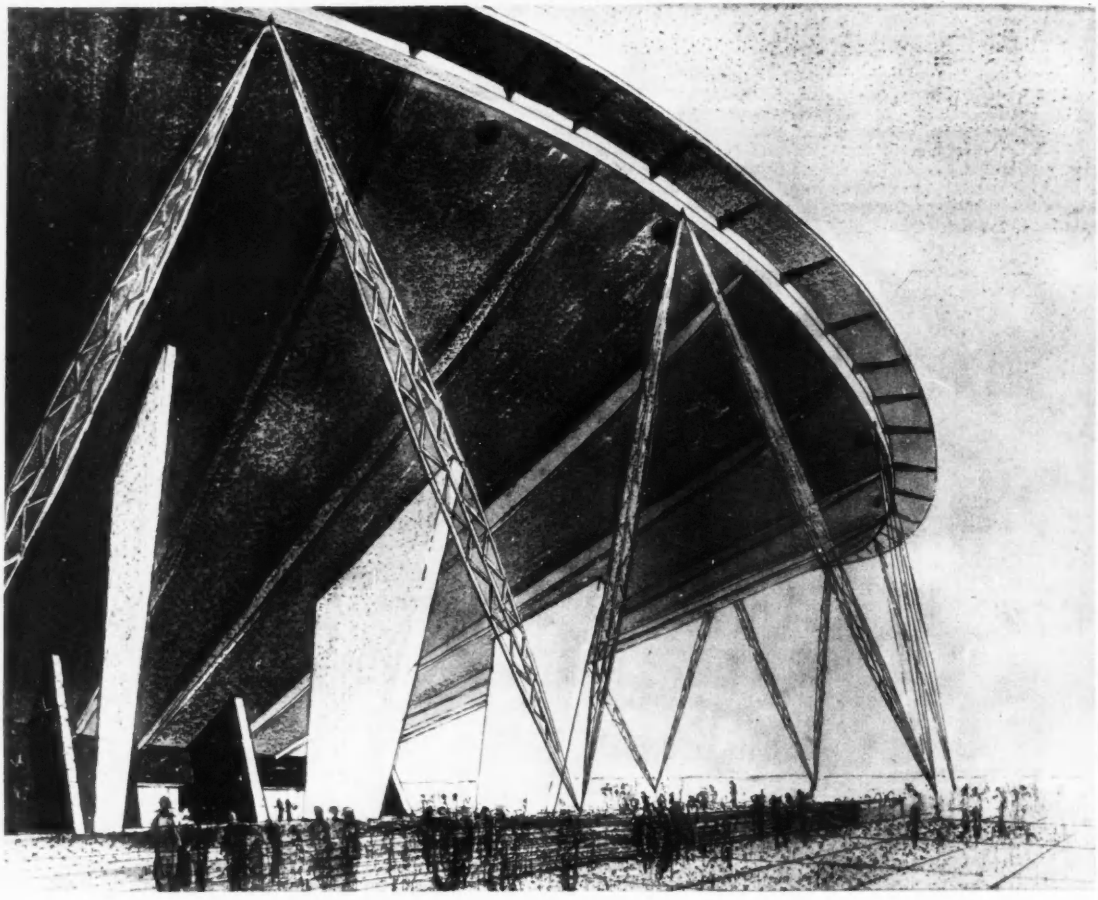


Discovery

Alongside the achievements of such men as Cook and Livingstone, will be displayed the discoveries of British scientists such as Newton, Darwin, Faraday, Thomson and Rutherford, without which so much that is illustrated elsewhere in the Exhibition would not have been possible. One section will display the latest knowledge of the structure and nature of matter, culminating in a display of nuclear energy. Others will be concerned with land, sea, and Polar exploration, Inner Space, Outer Space and the living world. Included in the displays will be British enterprise in the development of overseas territories, by new forms of survey, by research into local problems, by combating disease and difficult living conditions, and in short, by the yearly increasing knowledge of the earth, the sea, the sky and the plant and animal life of the world.

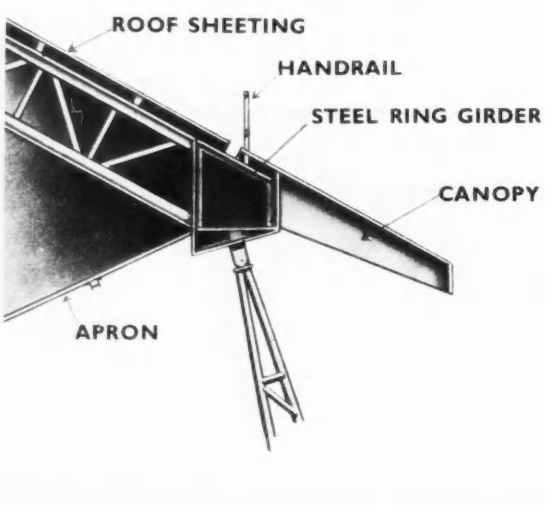


LAURENCE DUNN

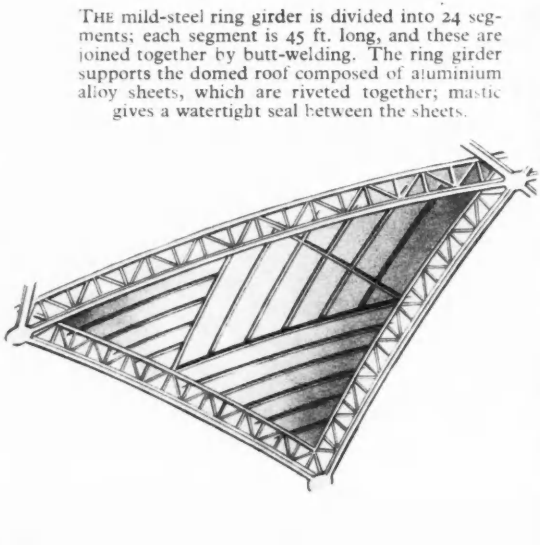


ARTIST'S IMPRESSION OF THE ENTRANCE TO THE DOME OF DISCOVERY

DETAILS OF ROOF STRUCTURE



THE mild-steel ring girder is divided into 24 segments; each segment is 45 ft. long, and these are joined together by butt-welding. The ring girder supports the domed roof composed of aluminium alloy sheets, which are riveted together; mastic gives a watertight seal between the sheets.



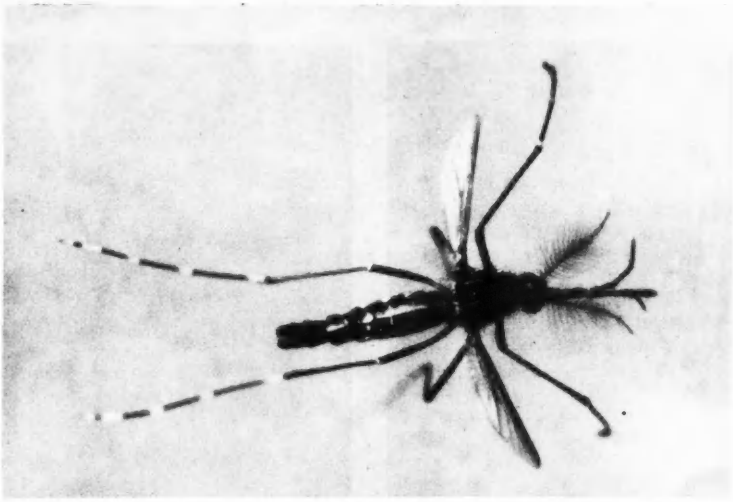


FIG. 1.—Flash photograph of a flying mosquito. The mosquito was photographed in flight by an Arditron flashtube which was triggered by an electronic device operated photo-electrically when the insect flew through the point of intersection of two narrow pencils of light. The camera was focussed on the intersection; the shutter was open so that exposure was made automatically at the instant that the insect flew into focus. *(Photo by Chemical Defence Experimental Establishment.)*

Electronic Flash Photography

ALAN HORDER

of Ilford Ltd.'s Technical Service.

THE term 'electronic flash' is the name generally used to describe photography with repeatable flash tubes, employing a sudden discharge of electricity through a gas, as distinct from flash bulbs containing combustible paste, wire or foil which give one flash only and then have to be discarded.

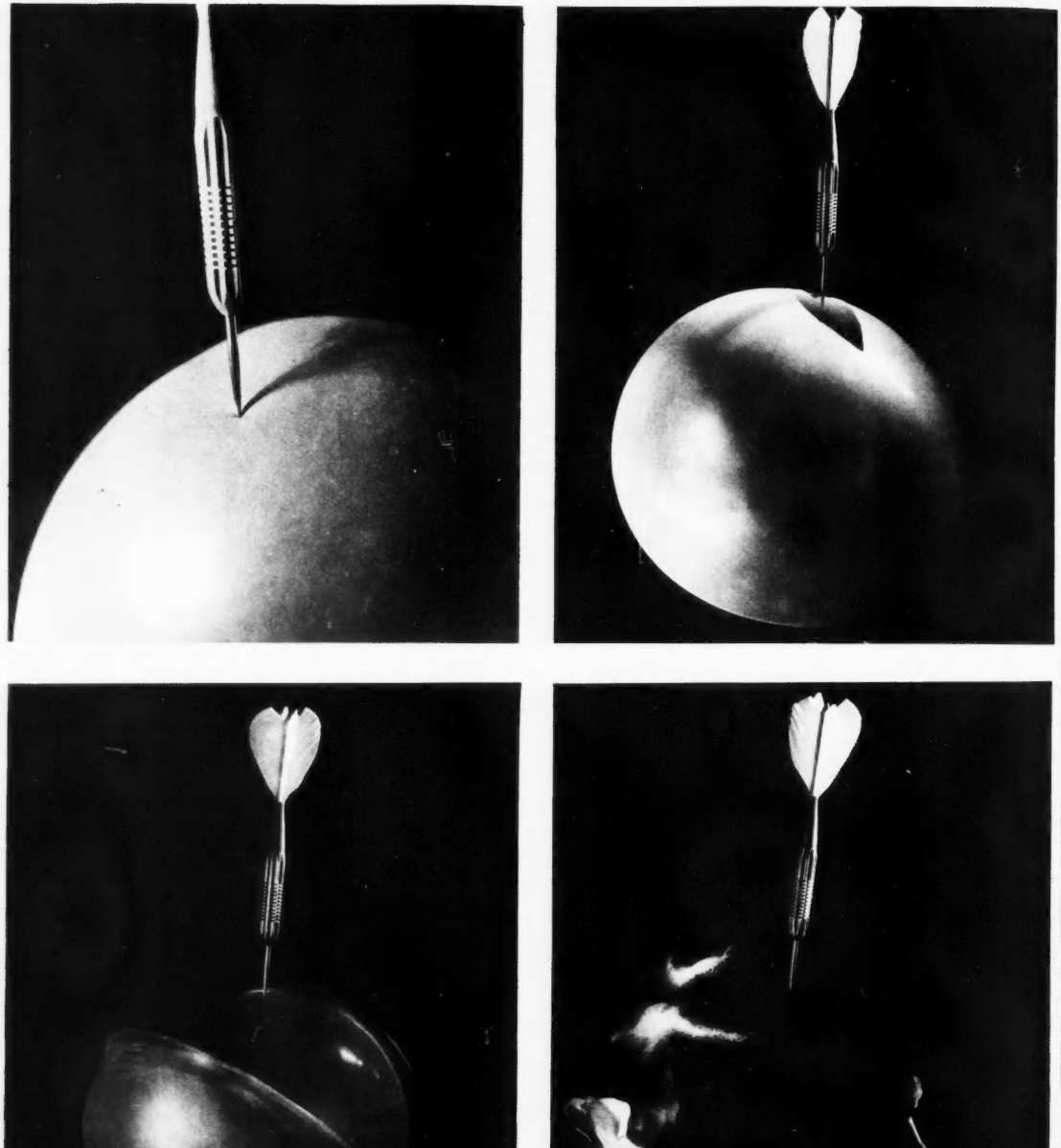
In the rapid development of this form of photography we have an example of the way in which a war-time development can sometimes be applied to peace-time needs. This is not to say that the invention of electronic flash was due to the war, for it had been in use for several years before then, but whereas in 1939 electronic flash was still largely a laboratory tool, today it is an everyday piece of equipment in the hands of the professional photographer and there is the prospect of its becoming available in a form, and at a price, suitable for the serious amateur in the not-too-distant future. It is the quickening of the process of harnessing this scientific discovery that we owe to World War II.

Before proceeding to discuss electronic flash in detail let us consider first some of the factors in photography which make such a light source desirable. As the word indicates, in photography we are concerned with recording by the agency of *light*: it is axiomatic that without light there is no photograph. Moreover, to obtain a useful record, the light available—i.e. the 'exposure'—must be not less than some minimum, the exact value of which will depend on the particular lens and photographic material employed. This desired exposure may be obtained by exposing the sensitive photographic material to a low intensity of light for a long time or to a high intensity for a short time.

When photographing stationary objects the choice of exposure time is largely governed by convenience, but with rapidly moving objects the exposure duration must be short if a sharp picture is to be obtained. The exact exposure time to be employed will depend on the speed of the moving object.

When describing high-speed photographs we sometimes say that the movement is 'frozen'. In fact, of course, the movement of the object—and of the image on the photographic film—is uninterrupted. The movement appears 'frozen' only because the exposure time is so short that the distance through which the image moves on the film is smaller than the eye can resolve, so that the picture is indistinguishable from that of a stationary object. The amount of image movement permissible is quite small, of the order of 1/100 in. in the final print, assuming that this is viewed at the nearest comfortable viewing distance of 10 in. This means that for very rapidly moving objects the permissible exposure time is extremely small.

The exposure time required to obtain a record depends on the light intensity, the lens aperture, and the photographic material employed, and it is possible by varying any or all of these factors to obtain exposure times suitable for most work. In outdoor work no attempt is usually made to control the light intensity (although this can be done) and variation of lens aperture provides the chief



Figs. 2–5.—A BALLOON BURSTS ON CONTACT WITH A DART

(Photos by V. L. Breeze)

control. For indoor work, however, control of illumination is obtained by selecting a suitable number of lamps of appropriate power.

In the early days of photography exposures of several minutes' duration were necessary in order to obtain an image. Today, wide-aperture lenses and fast emulsions have made exposures of 1/100th to 1/1000th of a second quite usual in outdoor photography.

In the photographic studio, however, a level of illumination much lower than that of daylight is generally employed. Higher levels of illumination obtained by conventional methods are costly to maintain and uncomfortable to work by. Thus for studio portraiture exposures of the order of half a second are quite usual. This duration is sufficiently short to give sharp pictures of adults, although for the photography of children shorter exposures are needed.

With daylight or conventional forms of artificial lighting a limitation to the shortness of the exposure times obtainable arises from mechanical factors. The shutters of cameras employed for still photography cannot generally be made to give exposures of less than 1/1000th of a second. While exposures such as this are quite short enough to 'freeze' action such as horse-racing, diving, and similar sport activities, there are many mechanical operations which cannot be photographed in this way. Similar considerations apply to cinematography.

To solve the problem of recording very rapidly moving objects we therefore turn from the camera to the light source. If this can be switched on and off very quickly we shall achieve the same effect as that given by a fast shutter in the camera. We must remember that we are attempting to obtain exposure times of a fraction of a thousandth of a second, so that ordinary lamps and switches will not be suitable. We must also remember that the shorter the duration of the period for which the subject is illuminated the stronger must that illumination be, to give adequate exposure to the photographic material.

The conventional flash bulb, containing combustible foil, or wire, gives a very bright flash which appears to the eye to be of brief duration, and at first glance would appear ideal for the purpose. In fact, however, the flash given by a typical bulb lasts for as long as 1/75th second, a duration which is far too long to stop rapid action.

For the solution of the problem let us therefore look back to the beginnings of photography.

The year 1839, in which Daguerre and Fox Talbot both announced their inventions, is taken as marking the beginning of photography. Yet as early as in 1851 Fox Talbot hit on the idea of using an electric spark as an illuminant for high-speed photography and took by this means a photograph of a small, rapidly rotating piece of *The Times*.

It is true that the illumination obtained from this spark was not great, but, what is to the point, its duration was exceedingly short, short enough in fact to give a perfectly sharp image of the rapidly moving newspaper.

Forty years elapsed before the spark method was put to any important use when, in 1892, Boys took pictures at approximately one millionth of a second and sharply recorded the silhouette of a bullet travelling at some 2000 feet per second. Boys produced his spark from current stored in Leyden jars and built up by a Wimshurst machine.

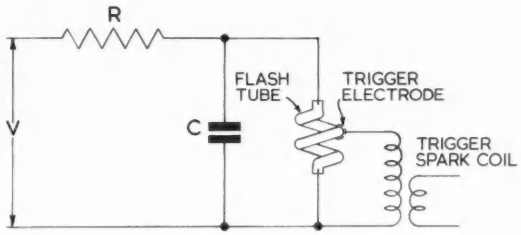


FIG. 6.—Basic flash-tube circuit.

From the point of view of the shortness of its duration, the spark is an almost ideal light source for high-speed photography but it has the drawback that the level of illumination is generally low and it is difficult to obtain reproducibility of results.

In 1931 Edgerton and his associates of the Massachusetts Institute of Technology, seeking a source of high illumination that could be flashed repeatedly, found that brighter and more reproducible flashes could be obtained by causing the spark to take place in a sealed tube containing mercury vapour. Edgerton saw the possibilities that lay behind this new light source and carried out considerable research on the electrical problems involved in supplying power for the tubes. He also worked on circuits that would give consistent timing and triggering of the flash.

Development proceeded steadily and by 1939 the first commercial electronic flash equipments were being marketed. Then the war saw giant electronic flash tubes in use for aerial photography by night, to make sharp, well-illuminated aerial pictures from altitudes of more than one mile, while other tubes of varying shape and size were employed for various branches of science.

Principle of the Flash Tube

The minimum requirements of any electronic flash equipment are a flash tube, a source of power supply, and some mechanism for operating the flash when required. The flash tube is essentially a device which can use the energy of a charged condenser to produce an electric spark. The spark takes place in a rare gas atmosphere which not only controls the quantity and quality of the light emitted but also protects the spark electrodes from oxidation and enables the flash to be repeated in a reproducible manner. In its modern form the tube consists of a long narrow glass tube, usually in the form of a close spiral to give a compact source. The spiral is normally protected by a glass envelope of about the size of an ordinary household lamp.

A very simplified circuit for such a tube is shown in Fig. 6. The condenser *C* from which the flash tube is operated is charged from a source of high voltage (usually about 2000 volts) through a current-limiting resistance *R*. The pressure of the gas in the tube is such that at the voltage to which the condenser is charged no flow of current takes place, but by applying to the external electrode a triggering voltage—a momentary pulse of a few thousand volts—the gas in the tube is ionised and permits the condenser to discharge rapidly through it with the accompaniment of a vivid flash.

It is desirable for black-and-white photography and

essential for colour photography that the colour of the flash shall be approximately white. A colour close to that of sunlight is preferred, and it has been found possible by suitable choice of the gas with which the tube is filled to obtain a light that is very acceptable in this respect. Xenon is almost universally used for the purpose and gives a light which, though containing rather more blue than sunlight, is perfectly suitable for black-and-white photography. For colour photography a pale converting filter over the camera lens is generally needed. The choice of the particular filter to be employed is governed by the colour film in use.

The duration of the flash depends on the design of the flash tube and on the condenser and associated circuit employed. Flash outfits used by press photographers and professional photographers in general give flashes of about 1/5000th second, but much shorter flashes are possible.

The range of the flash durations available is illustrated by the table showing the range of tubes supplied by one manufacturer.

The luminous intensity of the flash depends on the capacity of the condensers employed. Very bright flashes can be obtained by use of condensers of high capacity, but the duration of such flashes is necessarily longer than those obtained from smaller condensers. Again, large condensers are heavy and bulky and unsuitable for the photographer who must be able to transport his equipment from place to place without difficulty. In designing equipment for any particular purpose a balance has, therefore, to be struck between these various factors. A further factor to be considered is whether the power supply shall be taken from batteries or from the mains.

There are several ways of firing the flash tube. The simplest is to use special contacts on the camera shutter which operate via a relay or valve circuit. The shutter must be synchronised so that the flash takes place when the shutter blades are fully opened. Although the brightness of general room illumination is low compared with the flash it is generally advisable to use a fast shutter speed to prevent the possibility of a double image.

Type	*Joule rating watts/sec.*	*Approx. lumens/ sec.*	*Effective duration micro-sec.*	*General use*
LSD2	60	—	4	Ultra high-speed photography
LSD3 LSD3A	100	4,000	150	Lightweight studio or portable flash units
LSD4	400	26,000	300	Studio photography
LSD5	1,000	70,000	700	Studio photography
LSD7	200	10,000	200	Lightweight studio equipment
LSD10	10,000	700,000	—	Large-scale photography

Alternatively, the flash can be operated by using a microphone to pick up the noise of the event to be recorded, by electro-mechanical methods employing contacts in the path of the moving object, or, in the case of an event accompanied by light, by use of a photocell. Careful adjustment of all these devices is, of course, necessary to ensure that the flash takes place at the correct phase of the operation.

FIG. 7.—A living etenophore ("comb jelly") in marine plankton. Enlarged about 20 times. Electronic flash (about 1/3000 sec.) freezes the beating of the ciliary combs.

What Electronic Flash Will Do

The principal characteristics of the flash tube, namely, high luminous intensity, short duration, absence of heat, and good colour make it a very suitable light source for a variety of photographic purposes. These may be divided into applications in which electronic flash is indispensable, and others where it proves a great convenience although other types of lighting could be used as alternatives.

In the first group we have:

(1) *ophthalmic photography*, where the brief duration of the flash makes it possible to take photographs of the eye with the iris fully open, a task impossible with ordinary lighting;

(2) *bacteriological photomicrography*, where absence of heat during exposure is of great importance;

(3) *zoological photography*, of rapidly moving insects, birds, etc., such as mosquitoes, humming birds, chameleons;

(4) *the study of rapidly moving machinery, propellers, projectiles;*

(5) *the study of every-day events which happen too fast to be observed by the eye*—e.g., the breaking of an electric light bulb, the bursting of a balloon, the shuffling of a pack of cards.

Electronic flash has also proved a most useful source of illuminant for:

(1) *studio portraiture*, especially for work with children or whenever informal results are desired;

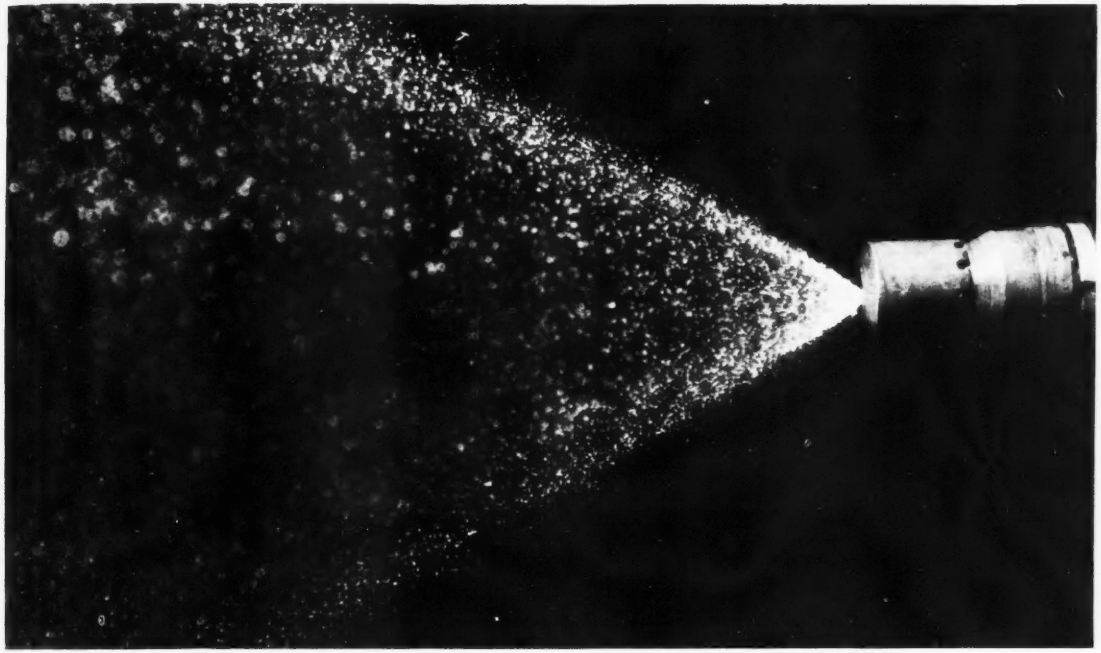


FIG. 8.—Fuel spray atomisation on burner test rigs using Ilford H.P.3 Plate, with an exposure estimated at 1 micro-second with 1 million candle-power illumination. (*Rolls Royce Ltd.*)

(2) *theatre photography*;

(3) *photography of tracks in Wilson cloud chambers*;

(4) *photography of the interiors of large buildings*, e.g. churches.

Although the flash tube was originally developed for high-speed photography it may well be that its greatest usefulness will finally prove to be in other less spectacular branches of photography, such as portraiture and medical work.

A portrait studio equipped for electronic flash will use, say, five flash tubes. Of these, four may be fitted in reflectors to the ceiling with cables running down a side wall to the power units, the remaining lamp being employed from the studio floor. There is no need to have a separate power unit for each flash tube: several tubes can be supplied from one unit, but unless additional condensers are employed the total light output of the tubes will only equal that of a single tube from the same power unit, and this must be allowed for in exposure. In addition to the flash tube in each reflector an ordinary tungsten filament lamp is fitted, generally inside the helix of the flash tube, to enable the photographer to study the effect produced by the lights. These are known as 'pilot' or 'modelling' lamps.

Studio work in which electronic flash has proved a real boon includes the photography of children and of wedding groups—where normally it is impossible to obtain a picture with all the group still without taking several negatives.

The above applications all concern the use of still cameras with flash equipment giving single flashes. With such equipment, a delay of 10 to 30 seconds is necessary before the equipment can be flashed again. Flash equipment capable of giving high intensity flashes at short intervals is also available and is used for high-speed cinematography. Thus tubes with a flash frequency of as high as 3000 per second have been used. These can be run for a few seconds only but this is quite long enough for the subjects with which this light source is required and enables a 100-ft. length of 16 mm. film to be exposed at one take.

The years immediately following the war saw the appearance of a bewildering array of commercial electronic flash equipment of all types. Some of it was good, some not so good. It has to be remembered that with equipment employing voltages of 2000 volts and upwards provision of first-rate insulation and safety devices is essential for the protection of the user. At the same time, as in the early days of wireless, many users of electronic flash were building their own equipment. This was partly due to the high cost (approximately £50–£100 or more) of commercial units. But prices have fallen. This is all to the good, for there was a danger that some photographers were becoming engrossed with the electrical side of their new 'toy' at the expense of the photographic.

Electronic flash employs normal photographic materials but sensitised materials behave somewhat differently at high speed from the way they do in ordinary photography. Consequently, as in other branches of photography, exposure and processing technique must be adapted to the work in hand if first quality results are to be obtained. This means that initially the photographer should be prepared to carry out experiments, based on manufacturers' recommendations for this type of work, until he obtains the type of negatives he requires.

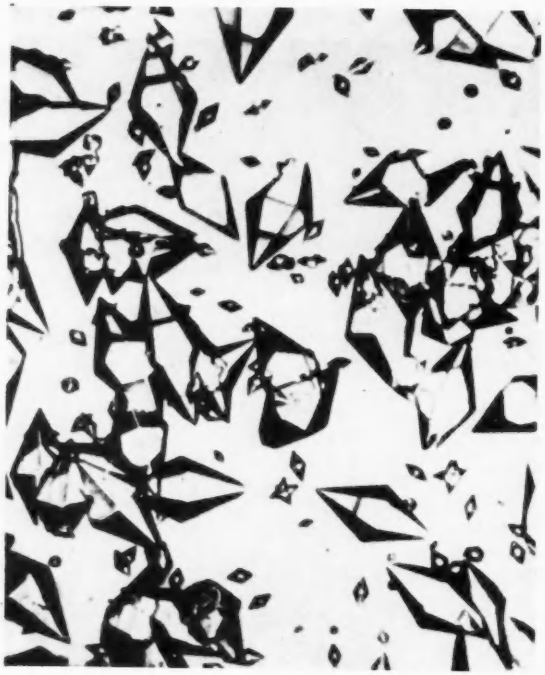


FIG. 1.—Photomicrograph of pepsin crystals. × 115 (from *Enzymes*, by Sumner and Somers).

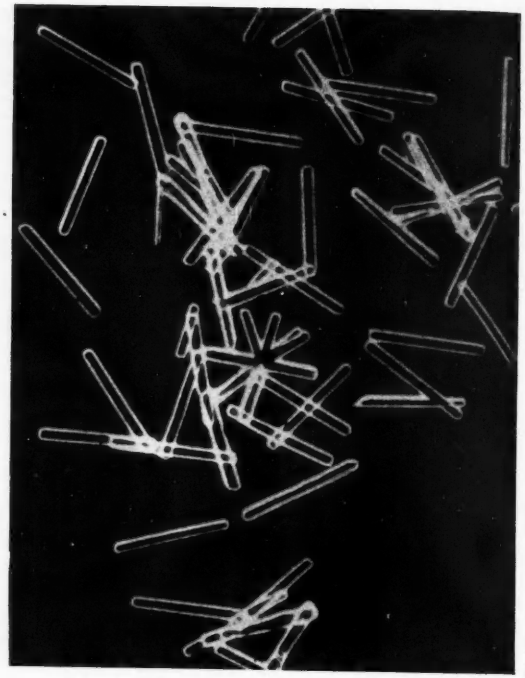


FIG. 2.—Photomicrograph of trypsin crystals. 350 (from *Crystalline Enzymes*, by Northrop, Kunitz and Herriott)

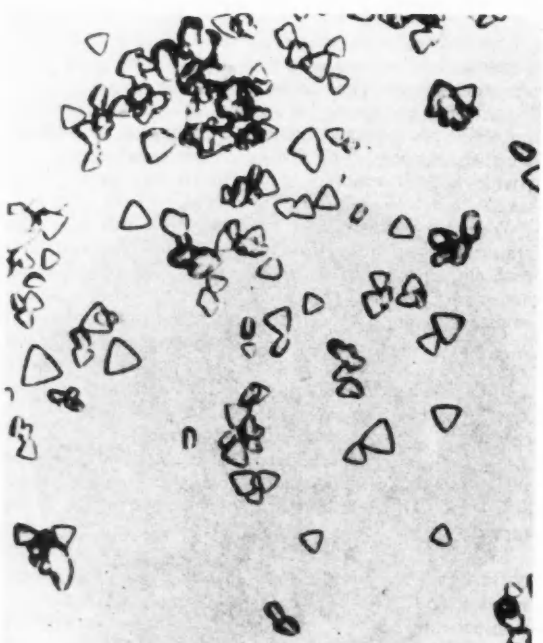


FIG. 3.—Photomicrograph of trypsinogen. × 350. This is the inactive precursor of the digestive enzyme trypsin. (from *Crystalline Enzymes*, by Northrop, Kunitz and Herriott).

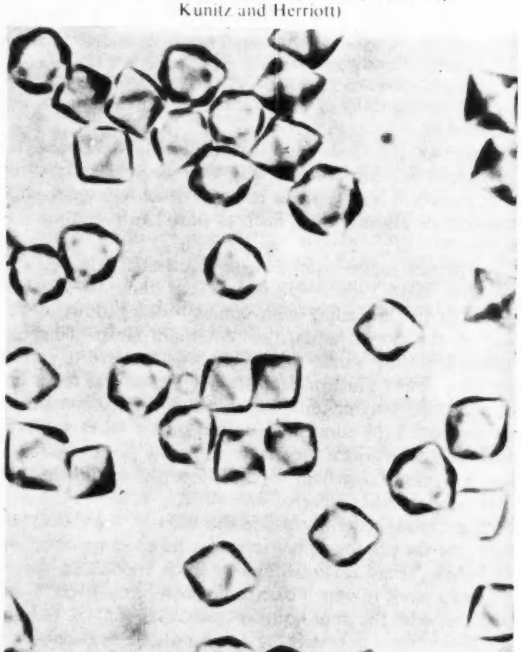


FIG. 4.—Photomicrograph of urease crystals. × 1100. This enzyme was the first one to be obtained as crystals, (from *Enzymes*, by Sumner and Somers).

Enzymes: Machine Tools of the Cellular Factory

B. A. KILBY, M.A., Ph.D., F.R.I.C.

THE first half of the present century has seen biochemistry develop from a humble servant of physiology into a master science in its own right. Its vast field of study is the chemistry of all forms of life, from the simplest bacteria to the higher plants and animals, and in this study it calls upon the services of almost every other branch of science. Much attention has been paid to the elucidation of the structure of the compounds which make up the living cell, and in recent years an increasing emphasis has been placed on studying how the cell functions. Much is known of the nature of the raw material entering the factory of the cell and of the products made there, and now the interest has switched to finding out more about the intricate machinery and processes which take place inside the factory. The machine tools of the cell are its *enzymes* or ferments which enable it to carry out the remarkable range of chemical reactions which make life possible.

There was a very vigorous discussion during the nineteenth century concerning the nature of fermentation. Why, it was asked, did insipid grape juice turn apparently spontaneously into wine—why did wort change into beer? What was the nature of the scum or sediment, the yeast, which appeared at the same time. In France, a prize equal in value to a kilogram of gold was offered in 1800 for the best answer to the question "What distinguishes substances which act as ferments from the materials they are capable of fermenting?" Although the prize was never awarded, its offer did much to stimulate discussion and controversy, as yeast was considered at that time to be a chemical by-product of fermentation, and it was widely believed that it played no essential part in the process. About 1837, three workers claimed independently to have shown that yeast was a living organism and was responsible for fermentation. This revolutionary view was received with scorn by orthodox chemists. Berzelius, the outstanding chemist of the day, reviewed this work scathingly in his chemical journal, while Wöhler wrote a sarcastic skit on the whole business which was published by Liebig in his *Annalen*. In this, yeast was described as consisting of eggs which hatched out into minute animals shaped like a distillation apparatus, into which sugar was taken as food and converted into alcohol and carbon dioxide, and the whole process could be observed quite easily under the microscope! Soon after this, Liebig set out his views on the nature of fermentation. Yeast played no part in his purely chemical theory which came to be widely held and was taught for many years afterwards. According to Liebig, the nitrogenous material in fruit juice was a ferment, unstable in the presence of air, which caused it to undergo a progressive change. While this change was in progress, the ferment communicated its instability to the sugar, which then broke down into alcohol and carbon dioxide. Liebig was able to produce chemical analogies for this; for example, silver is dissolved readily by nitric acid but platinum is quite unaffected, yet an alloy of the two dissolved quite easily and completely. This was, he said, because the silver, in dissolving, communicated its instability to the platinum. Louis Pasteur, on the other hand, strongly opposed these non-vitalistic ideas, and developed his thesis of *No fermentation without life*. He said that alcoholic fermentation never occurred "without the simultaneous organisation, development, multiplication of cells or the continued life of cells already formed". It was true that Pasteur had to distinguish between what he called the 'organised ferments' as in yeast, and the 'unorganised ferments' (such as *pepsin* which is secreted into the stomach or *ptyalin* of saliva, which breaks down starch), since such unorganised ferments could be shown to act in a test-tube.

After prolonged discussion, during which no new decisive experimental evidence was obtained, the Pasteur-Liebig controversy was suddenly settled by a fortuitous and lucky observation of Hans and Eduard Buchner in 1897. This discovery is one of the notable milestones in the long path of physiological chemistry, and many regard it as marking the beginning of modern biochemistry. The Buchners had previously found that the cells of bacteria could be disrupted by grinding with sand, and they extended their technique to yeast cells. The macerated product obtained in this manner contained much cell debris and it was very difficult to separate liquid from it, so they modified the method by adding kieselguhr, an inert and porous earth, to the yeast cells and sand. After grinding, a mass which had the consistency of dough was obtained; this was wrapped in cloth and submitted to a pressure of about 1500 lb. to the square inch in a hydraulic press. An opalescent brownish-yellow juice was obtained which was free from yeast cells and this was used for a number of animal experiments. It was not altogether satisfactory as it soon putrefied. The nature of the experiments excluded the addition of the usual antiseptics, so the Buchners decided to add sugar as a preservative. To their surprise, fermentation began immediately, the sugar being converted into alcohol in spite of the complete absence of living yeast cells.

Pasteur's thesis was thus disproved. But closer consideration shows that both Pasteur and Liebig were partly right and partly wrong. Fermentation could take place in the absence of living organisms, and it was chemical in nature but not in the way Liebig had thought. Certain ferments were produced by the living yeast and normally functioned inside the cell to cause the breakdown of the sugar which was serving as a food for the yeast. The nature of the yeast used in making active juice is rather important. Some strains, such as Munich 'bottom' yeast (which rapidly settles to the bottom of fermentation vats) gives active juices, whereas others, including some Parisian and English 'top' yeasts (which form a thick scum on the surface) give quite inactive juices. It is possible that Pasteur may have experimented with such a 'top' yeast and been unable to prepare any active extracts. A more fortunate selection might have enabled him to anticipate the Buchners by more than thirty years.

The production of this active juice meant that it was no longer necessary to consider the possibility of some mysterious vital force as being concerned in fermentation. The mystery should be explicable in purely chemical terms. The

juice could be easily made in quantity, and an immense amount of work has since been done on its properties. Its activity was originally ascribed to the presence of a ferment called *zymase*, but it is now known that the breakdown of sugar into alcohol involves at least fifteen separate and successive stages, and almost as many ferments or *enzymes*. The unravelling of the intricacies of alcoholic fermentation and the isolation of many of the intermediate compounds and separate enzymes are among the great triumphs of biochemistry. In 1925, Meyerhof published a method for preparing a juice from muscle which would convert, in a test-tube glycogen (the animal analogue of starch) into lactic acid, a change which is known to occur in living muscle and to provide the energy for contraction. This conversion also has been found to take place in about fifteen stages, which, except for the initial and final ones, are identical with those in yeast. This is a good example of the essential unity of biochemistry, where living organisms of widely different character are found to involve the same biochemical processes, with slight modifications to suit their particular needs.

When evidence has been obtained for the existence of some interesting new natural product, one of the first aims of the research worker is to try and isolate it in the pure state. Stage by stage, inert matter is removed from the crude product, and the progress of purification can often be followed by observing an increase in a particular biological activity per unit weight. If the worker is lucky, he may eventually obtain the pure material which shows a constant and maximum biological activity, unchanged after going through the motions of a further purification. The research worker is most happy if his product turns out to be a crystalline solid, as purification by recrystallisation is often one of the easiest techniques, especially if it becomes necessary to work on a small scale because of scarcity of material. Crystals usually have well-defined physical properties which are valuable criteria of purity. As soon as it was realised that biological material, such as yeast juice or gastric juice from the stomach, probably owed their activities to the presence of specific enzymes, efforts were made to try and isolate these for precise examination. For many years, the final products obtained were non-crystalline solids and it was suspected that they were still impure, in spite of showing very high enzymatic activity. These products consisted largely of protein material, and it has always been rather difficult to resolve mixtures which contain proteins into pure components. However, so consistently was high enzymatic activity in these final products associated with protein material, that many workers believed that the enzymes were themselves proteins. A German school on the other hand held that the enzyme was really a relatively simple chemical substance which was absorbed on to the protein material which acted as an inert carrier. However, in 1926, the first enzyme was obtained as crystals and found to be a pure protein. The method used in this particular case was remarkably simple. There is an enzyme *urease*—which breaks down urea into ammonia, water and carbon dioxide. This enzyme is fairly widespread in nature, soya beans being quite a good source, but the best is the seeds of the Jack bean (*Canavalia ensiformis*). The ground beans from which the fat has been extracted are available commercially as a source of urease, under the name of Jack Bean meal. The American chemist, Sumner extracted the meal with 31·6% aqueous acetone and filtered the solution in a cold room. After standing overnight, very small octahedral crystals separated out, which were about 730 times as active as the original meal in splitting urea.

Crystalline Enzymes

Since that time, about twenty other enzymes have been obtained in crystalline form by various workers, but usually only by more elaborate and more lengthy methods. Attempts to crystallise many other enzymes have not yet been successful, but this is not a serious handicap to the biochemist as he can obtain a great deal of information about the properties of an enzyme without having the pure material. A solution or suspension containing a particular enzyme can often be made quite readily from a suitable source and used to investigate what changes the enzyme can bring about, how it is affected by heat, different acidities, poisons and so on. The biochemist has a wide range of biological material from which to select a convenient and rich source of the particular enzyme which interests him; typical examples of the materials employed are red blood cells, meal worms, mushrooms, bacteria, pigeon breast muscle, rat liver, beef pancreas, and horseradish.

All the enzymes which have been obtained pure and crystalline have shown the properties of proteins and it would appear that each pure enzyme is a quite definite chemical compound, a protein with characteristic and constant properties. Some enzymes have a purely protein structure, but others have, in addition, some relatively simple unit of a different nature built into the structure as an essential part.

Co-enzymes

Other enzymes can only function if certain compounds, called *co-enzymes*, are also present. If yeast juice, for example, is placed in a cellophane bag and washed in a current of water, the co-enzyme passes through the cellophane because it has a small molecule and is washed away, while the large protein enzymes are left in the bag. This residual juice will be found to have lost its power to cause fermentation. If another sample of yeast juice is boiled, the enzymes are destroyed but not the heat stable co-enzyme. This solution is also inactive, but if the two preparations are mixed, then the combination shows biological activity again as both enzyme and co-enzyme are present.

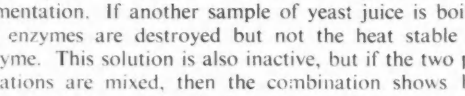


FIG. 5.—Models of the two forms of lactic acid, $CH_3CH(OH)COOH$, which are mirror images. These models give the best representation that is possible of the actual shape of molecules. (From *Organic Chemistry*, by L. F. and M. Fiezer.)

A slightly different co-enzyme has been found in red blood cells, and in 1935 both co-enzymes were shown to contain the substance *nicotinamide* built into their structures. Almost exactly at the same time, Elvehjen and his associates discovered that nicotinamide was the vitamin present in diets which would prevent and cure human pellagra. Thus a memorable link-up occurred between two of the major lines of biochemical study—of vitamins and nutrition on the one hand and of enzymology on the other—to their mutual advantage. It became possible to ascribe a definite biochemical function to a vitamin, and new light could be thrown on possible chemical mechanisms of enzyme systems by a study of the chemical properties of the vitamins.

Another example of a vitamin associated with an enzyme is afforded by vitamin B_1 or aneurin, which prevents beri-beri. In combination with phosphoric acid this vitamin acts as the co-enzyme for an *oxidase*, an enzyme which breaks down pyruvic acid. If this vitamin is deficient in the diet, the oxidase cannot function and pyruvic acid accumulates in the tissues, a change which can be used in the clinical diagnosis of vitamin B_1 deficiency. If the vitamin is supplied in the diet, the pyruvic acid soon disappears.

Several other vitamins have now been identified as parts of the structure of different co-enzymes or of the non-protein part of enzymes, but not all vitamins have yet been associated with specific enzyme systems and it is probable that some may function in other ways.

A Little Goes a Long Way

A little enzyme goes a long way—for instance, one part of *rennin* is capable of clotting ten million times its weight of milk—so that the absolute amounts of enzymes required for the smooth running of the body may be quite small, and only small amounts of vitamins will be required for building new enzymes and co-enzymes to make good the small but continuous loss through general wear and tear. The body cannot make the vitamins itself and without them some enzyme systems cannot function. The requirements of vitamins are thus small but essential, and if not met, the machinery of the whole body may get disorganised and death may eventually take place.

The substance which is transformed in the presence of an enzyme is called the *substrate*. Some enzymes can bring about changes with a large range of different but related compounds; some *lipases*, for example, will bring about the splitting of many different fats. Other enzymes, such as urease, may be so selective that they will transform only a single kind of substrate. It is believed that in general before an enzyme can bring about a reaction, a complex must first be formed between the enzyme and the substrate. This theory is based largely upon mathematical analysis of the shapes of reaction-time curves, but in a few cases, direct experimental evidence to support it has been obtained. The enzyme *peroxidase* brings about the oxidation of certain compounds by hydrogen peroxide. A sharp change in colour of peroxidase occurs when hydrogen peroxide is added to it indicating the formation of a complex; if a suitable substrate is now added, oxidation takes place, the hydrogen peroxide is used up and the original colour of the peroxidase reappears. It is generally accepted also that this combination with the substrate can only take

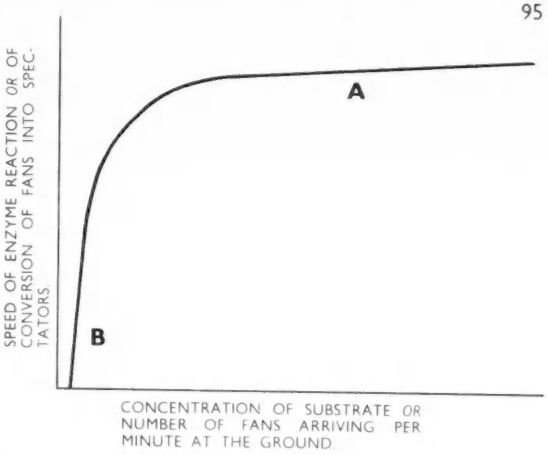

SPEED OF ENZYME REACTION OR OF CONVERSION OF FANS INTO SPECTATORS
A
B
CONCENTRATION OF SUBSTRATE OR NUMBER OF FANS ARRIVING PER MINUTE AT THE GROUND

FIG. 6. Relationship between rate of enzymatic reaction and the substrate concentration. A similar curve would be obtained by plotting the rate of the "football crowd" reaction and rate of arrival of fans mentioned in the text.

place at a special point in the enzyme structure, called the *active centre*. Successful formation of a complex may depend on the degree to which the shapes of the active centre and substrate are complementary. Emil Fischer used the analogy of a lock and key to illustrate this point. Many substances exist in two forms, whose molecular structures are mirror images of each other (rather like a pair of gloves) and in such cases, it is nearly always found that only one form will work with the enzyme. The two forms of lactic acid are shown in Fig. 5, and the enzyme *lactic dehydrogenase* which removes two hydrogen atoms to convert lactic acid into pyruvic acid will function with the naturally-occurring form, but not with the other, its mirror image. The active centre might be thought of as a hand and the lactic acid as a glove, when only one glove of the pair will fit the hand.

When an enzyme reaction takes place, one may picture the substrate molecule colliding with the active centre, forming a complex, reaction occurring and the products then leaving the centre which is then free for another cycle to take place. The enzyme molecule (if it has a single active centre) can thus deal only with a single molecule of substrate at a time, but the cycle may be repeated very rapidly; a single molecule of *catalase*, for instance, can break up at least five million molecules of hydrogen peroxide in a minute. When measurements are made of the speed of an enzyme reaction in the presence of increasing amounts of substrate, a curve of the type shown in Fig. 6 is usually obtained. This has the form of a rectangular hyperbola. If there is ample substrate, the enzyme is working full out all the time and increasing the concentration of substrate has little effect as at A. At low concentrations of substrate, as at B, the active centres are unoccupied for much of the time, and so increasing the amount of substrate has a direct and proportional effect on the speed.

As an analogy, one might consider a crowd of football fans waiting to enter a football ground. The individual fans are the molecules of the substrate, and the turnstiles are the active centres of the enzyme which transform fans

into spectators one at a time, As long as there are enough people to keep the turnstiles going at full speed, the rate of change of fans into spectators will be constant and independent of the length of the queues; but if only a few people approach, they will go in without waiting and the rate of conversion of fans will be directly proportional to the number arriving at the ground. One might extend the analogy by comparing certain vitamins to the oil necessary to lubricate the turnstile mechanism. If this is lacking, the turnstile will seize up and chaos result.

The number of different enzymes already known is very large, and new ones are constantly being found. The discovery of penicillin was followed very quickly by the discovery of *penicillinase*, the enzyme which destroys it.

Every species of plant and animal seems to possess its own set of enzymes which do not correspond exactly to similar enzymes present in other species, so that the total number of individual enzymes may run into many millions. Innumerable compounds occur naturally in plants and animals and for each there must exist enzymes which can make and break them down. Enzymes enable living organisms to carry out a great variety of reactions in dilute aqueous solution at temperatures between freezing point and blood heat; there is no need for extremes of acidity or alkalinity. Without using enzymes, the organic chemist can carry out only some of these changes, and then often he may have to use higher temperatures, corrosive reagents and concentrated reagents and sometimes to exclude water completely.

Theories of Enzyme Action

In short, life as we know it could not exist without enzymes.

Various theories have been proposed to try and explain how enzymes can so modify chemical reactions that they will occur under such mild conditions. The general idea of the most widely held theory is as follows; suppose a molecule, say A–B, is too firmly bound together for breakage of the bond between A and B to occur easily, then if complex formation takes place with an enzyme, the forces holding the complex together may lead to a redistribution of forces within A–B such that the linkage is so weakened that fission can occur and A and B are formed. This idea is shown pictorially in Fig. 7., but it must not be taken too literally.

Anything which can inhibit or stop vital enzymes from functioning smoothly in the organism may lead to its death. The absence of certain vitamins is one example already mentioned. Heat and ultra-violet light may produce irreversible changes in the protein molecule, and if this protein is an enzyme, loss of activity results. Another way in which an enzyme may be inhibited is by some compound reacting chemically with it or forming a stable complex at the active centre, which is then blocked and cannot fulfil its normal role any longer. One fat man firmly wedged in the turnstile might stop the 'football crowd' reaction.

The highly poisonous nature of some compounds has been correlated with their ability to 'knock-out' certain important enzymes, so that only a small amount of such poisons may be necessary to produce very serious effects on the well-being of the whole organism. One part of mercuric chloride in 200 million parts of solution will reduce by half the efficiency of the enzyme catalase. Cyanide is very efficient at stopping the working of some of the enzymes concerned with oxidation, while some of the highly toxic phosphorus insecticides are extremely potent inhibitors of cholinesterases (enzymes which play an essential part in the working of the nervous system of higher animals, and probably also of insects).

The existence of anti-enzymes in living systems has been demonstrated. One of the best examples is shown by the round worm, *Ascaris*, which lives in the animal intestine and escapes being digested by the enzymes present by producing specific enzymes which neutralise the effect of specific digestive enzymes. However, if the worms are placed in dilute solutions of digestive enzymes from plants (such as *ficin* from the latex of certain fig trees), they are digested alive as they lack specific inhibitors to these unfamiliar enzymes.

An intriguing problem is why digestive enzymes do not attack and digest the glands producing them, or the intestinal tract into which they are secreted One reason may be that such enzymes are usually secreted in an inactive form, and the active centre is 'uncovered' later. The pancreas secretes *trypsinogen*, which is inactive but is converted into active *trypsin* in the intestines. The stomach secretes a mucilage which coats its walls and probably protects them from the action of the digestive juice.

When biochemical processes are examined in detail, it is often found that a change, such as the fermentation of sugar or the oxidation of acetic acid to carbon dioxide and water, is not achieved by a single enzyme but by a whole battery of them. There may be a dozen or more stages each brought about by a separate enzyme. The substrate has therefore to move from one enzyme to another, and at each stage some modification in structure occurs. It is difficult to see how this could take place smoothly and efficiently in the cell if all the enzymes in a battery were scattered throughout the volume of a cell. One might suspect that they would be found to be arranged in an orderly sequence, like the machine tools along the production line of a factory, so that the material undergoing transformation can pass easily from one enzyme in the series to the next. Recent discoveries have indicated that this may sometimes be the case. Various small granules called *mitochondria* exist in the cytoplasm of cells (the cytoplasm is the part of a cell outside the nucleus) and most of the enzymes concerned with oxidation appear to be concentrated in these granules, which may be thought of as the powerhouses of the cell, since the principal purpose of oxidation is to release energy. Not a great deal is known yet about the structure of mitochondria, or how they are reproduced or of the arrangement of enzymes in them. Handcuffed together, as it were, the enzymes act as a group and their collective behaviour may differ from the sum of that previously observed for the individual enzymes which the biochemist has obtained after destruction of the unit. The study of enzymes began with the living cell and then progressed to the isolated enzyme. The main aim of this phase, the classical period of enzyme biochemistry, has been to separate an enzyme from all others that accompany it; the isolation of crystalline enzymes marks the triumph of this technique. This phase is so productive of results that it will be developed for a long time yet, but at the same time another approach is being fostered. The aim of this is not the separation of enzymes from each other but the avoidance

of this in order to obtain intact teams of enzymes and study the activity of the team.

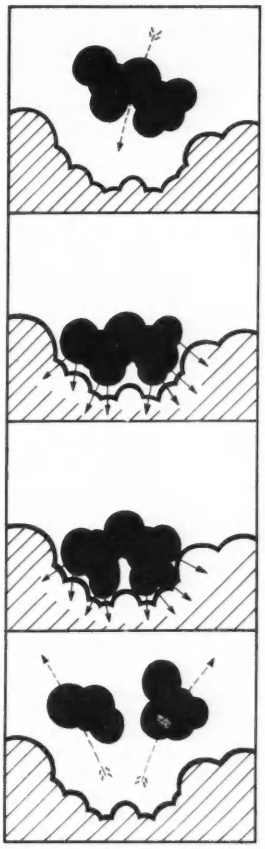
The activities of enzymes are not the concern merely of the academic biochemist or the brewer, for enzymes are involved in many aspects of everyday life. The housewife makes junkets by using rennet, a preparation containing *rennin* which converts caseinogen a soluble protein of milk, into casein, whose insoluble calcium salts separates out as the curds. The natural function of this enzyme (which occurs naturally in the fourth stomach of the calf) is probably to delay the emptying of the stomach by converting liquid milk into a jelly-like mass.

Meat is hung to make it tender, as animal tissues after death undergo self-digestion owing to the presence of enzymes which partly degrade some of the structural material of the tissues. The oxidising agents added by millers to flour as 'improvers' and in order to bleach it, inhibit the *proteinases* of the wheat which, if left active, would alter the proteins present in the flour and give rise to a less satisfactory bread. The 'rising' of dough is due to the action of enzymes in the flour and added yeast; these cause breakdown of starch into sugars which the yeast ferments to produce carbon dioxide, the gas which makes the dough rise, as well as a little alcohol, some organic acids and materials with pleasing flavours. It is enzymes which make apples and potatoes go brown after cutting, a change due to the enzymatic oxidation in air of certain colourless compounds present to form pigmented substances. Many industrial processes are based on enzymatic action; usually living organisms such as yeast, moulds or fungi, are used, as, for example, in the manufacture of malt vinegar, penicillin, citric acid and so on; a discussion of these is rather outside the scope of the present article.

Two examples can however be mentioned of industrial processes which use special enzyme preparations, as opposed to living organisms. When fruit juices are being manufactured, *pectins* which form a part of the structure of plant cells, may separate out from solution as gelatinous precipitates and make filtration difficult or spoil the appearance of the product. (If pectins are present in sufficient amount, a fairly rigid jelly may result, as in successful jam making.) Clarification of fruit juice drinks is now achieved usually by adding *pectinases*, enzymes which degrade pectins to soluble products. The enzyme preparations used are made from certain moulds grown for the purpose. At one stage in leather manufacture, it is necessary to remove degraded products of hair, glands and certain tissue proteins from the hides. This used to be a secret process which involved soaking the hides in a warm suspension of dog dung. The same result is now achieved more pleasantly by using enzymes prepared from large scale cultures of suitable strains of bacteria.

Human life begins with an enzymatic reaction. Spermatazoa liberate *hyaluronidase*, an enzyme which attacks the envelope around the egg and allows a single spermatazoon to enter and fertilise it. Enzymes keep the flame of life burning until death, when enzymatic decomposition returns the building material to the great store from which fresh life can draw its raw materials to be assimilated and rebuilt into new life forms.

The living cell may be pictured as a remarkable factory, which not only makes a vast range of different products simultaneously, but also builds its own extensions, does its own repairs and makes its own machine tools. Changes in the nature of the raw materials available or sudden demands for material for new tissue building do not change the smooth running efficiency of this factory. An elaborate control system must be operating which regulates the speed at which the different machine tools are working and thus which departments must speed up production, and which slow it down. The chemical regulators of the body are its hormones, and these must almost certainly act by controlling key enzyme reactions. The first indications that this may be so have been obtained, and it may well be that the major development in biochemistry during the next half century will be a greater understanding of the mechanism of hormone action in terms of enzyme reactions. Much has been achieved in enzymology, but very much yet remains to be done. It would be an over-confident biochemist who would consider himself worthy of the kilogram of gold.



The substrate molecule approaches the active centre on the enzyme surface.

An enzyme-substrate complex is formed, if the shapes and reactivities of the two parts are favourable.

The binding forces lead to the weakening of a chemical bond in the substrate molecule.

Fission occurs, and the two fragments leave the active centre which is free for another cycle to occur. The fragments may be highly reactive, and may combine with other substances.

READING LIST

Man is a Microcosm, by J. A. V. Butler (Macmillan, 1950) includes a popular account of enzymes. *Dynamic Aspects of Biochemistry* by Ernest Baldwin (Cambridge University Press, 1947) is concerned largely with enzymes. Good standard text-books at a more advanced level include *Chemistry and Methods of Enzymes* by J. B. Sumner and G. F. Somers (Academic Press, New York, 1947), *Crystalline Enzymes* by J. H. Northrop, M. Kunitz and R. M. Herriott (Columbia University Press, 1948) and *Enzyme Technology* by Henry Tauber (John Wiley, New York, 1943).

The Bookshelf

Out of My Later Years. By Albert Einstein. (London, Thames & Hudson, 1950, pp. 282, 15*s*.)

IN 1949, Albert Einstein, now in his seventieth year, collected into a single volume his various writings since 1936. The book, now published in London—Thames and Hudson, 15*s*.—consists more of comments on the life of our times than of scientific material; nevertheless it is writing the scientific worker should not miss. Inevitably we think of Einstein as a phenomenon; this book shows him as a man—a shrewd, kindly fellow who has thought about many more things than Relativity, and always with detachment, always with warmth.

To have thus retained his balance is a considerable feat. Consider the strange background to his theories. Ten years old, he finds himself a Jew in a Christian School where, moved by priestly oratory (though not in the way the Priest intended), his school fellows beat him up to avenge a two-thousand-year-old wrong. He isn't thought very bright at school, and at twenty-five is lucky to hold a very minor post in the Swiss Patent Office. There, as a by-product of official activity, he overturns the universe of space and time. The end of the First World War finds him despised in Germany as a Pacifist and outside Germany as a Boche. Then in 1919 a British Expedition to observe an eclipse of the sun finds striking proof of his theories, and all at once he is one of the two or three names that everyone has heard of.

Fame and fortune are his. But soon he is to see his work denounced bitterly, in Germany, by the Nazis, to whom its complexities are evidence of debased blood; in Russia by the Stalinists who consider it bourgeois intellectualism. Read with these facts in mind, his essays on Morals and emotion, Socialism, the Negro question, Zionism, and Peace are remarkable documents. Add to them a classic essay of "Physics and Reality", notes on Time, Space and Gravitation, and a brief derivation of E equals Mc2 from pendulum mechanics, and the result is a volume essential for everyone engaged in science. In fact, of the fifty essays in the book—which include brief studies of Newton, Kepler, Planck, and a note on atomic war, there is not one that is not in some strange way electric.

As for the communication entitled, "Dr. Einstein's mistaken notions", sent to him by Vavilov (Physicist), Frumkin (Colloid Chemist), Joffe (Crystallographer) and Semyonov, Director of the Institute of Chemical Physics at Moscow—this, though it concerns his belief in world Government and not his Theory, is none the less valuable as evidence of Stalinist thought. As for the spirit of the book, these lines from Einstein's brief self-portrait convey it perfectly: "I do the thing which my own nature drives me to do. It is embarrassing to earn so much respect and love for it."

C. TROKE.

Spotlight on Animals. By Chapman Pincher. (London, Hutchinson, 1950, pp. 188, 50 illustrations, 12*s*. 6*d*.)

BOOKS dealing with curiosities of animal life have been popular for centuries, and will doubtless continue to appear in the future. Modern science has added much to the interest of such volumes at the same time as it has diminished the mystery of various subjects. Chapman Pincher's volume is a case in point: here are all the old favourites—how a bee finds its way—how a bat avoids collisions—to what ages do animals live? These topics are presented in the form of popular accounts of the latest results of scientific research, rather than as unexplored marvels of a mysterious animal kingdom.

This is a readable, entertaining, and up-to-date account of many of the former 'mysteries' of animal life.

P. B. C.

A Hundred Years of Physics. By William Wilson, F.R.S. (London, Gerald Duckworth, 1950, pp. 308, 21*s*.)

SIMPLE faith may be more than Norman blood but it still is not enough to convince me that this book is for the general reader. Professor Wilson even protests: "It is hardly an exaggeration to say that mathematics is absent in most of the chapters." The facts belie him; out of the 308 pages, 156—more than half the total—have mathematics of some sort on them.

All this mistaken zeal for persuading the layman that the work is just his cup of tea is to be regretted, for the truth must be stated that this is an excellent book, just the very thing for anyone of sufficient education who wants to learn the authentic facts of the developments of the past century. It is a first-rate piece of exposition by a physics teacher who has spent his life with his subject and has actually contributed modestly to some of the developments. Three-quarters of the past century have actually been in Professor Wilson's lifetime, and he contributed the article on quantum theory in the 14th edition of the *Encyclopaedia Britannica*. If he had done nothing else but write the present book he would still have made a significant contribution to the exposition of difficult subjects.

He sees the century's developments as a sort of epic, as indeed it is, with a prologue and an epilogue. In the former he gives a rapid resumé of the state of knowledge in 1850; in the latter he suggests possible future developments. In between come the twenty-one chapters of the text, the discussion being centred mainly on thermodynamics, the nature of light, electromagnetics, relativity, radiation, electrical conduction, atomic structure, fundamental particles, and astrophysics. All these topics are discussed at about the level of a serious reader who has reached at best matriculation standard in mathematics and can remember it. The exposition is occasionally enlivened by revealing ornaments. Thus in a footnote to a discussion of the General Theory of Relativity he writes: "The word 'curvature', it is perhaps unnecessary to state, is used here in a very Pickwickian sense. It means something whose mathematical expression has a similar *form* to that for the curvature of a curved Euclidean surface." In this one sentence Professor Wilson disposes of the mystical twaddle to which some of us have been subjected on the topic of the curvature of space.

This is a book to be recommended to all serious students of physics.

C. L. BOLTZ.

Cell Growth and Cell Function. By Professor T. O. Caspersson. (London, Chapman & Hall, 1950, pp. 185, illus., 28*s*.)

THIS book is based on a series of lectures given by the author in 1948 and is a review of the work of the Stockholm School over the past fifteen years. The author's name will always be associated with the foundation of ultra-violet microspectrophotometric methods, and that of his school is outstanding in the field of cytochemistry. In view of the prevailing uncertainty as to the reliability of microspectrophotometric measurements, cytologists and biochemists will alike be grateful for the author's revealing analysis of technique given in the early chapters. The later chapters, which are somewhat less satisfactory, deal with ultra-violet light absorption data relating to specific biological problems and the author's speculations arising from them. In the opinion of the reviewer, microspectrophotometric investigations provide information on probable correlations between intracellular processes, but do not by themselves provide rigorous proof for relationships within the confines of the cell.

H. G. CALLAN.

Progress in Photography

A BOOK, *Progress in Photography*, just published (Focal Press, London and New York, 1951, pp. 460, illus., 2 guineas), will appeal to everyone interested in developments in the fundamental aspects of photography and cinematography and their application. It contains up-to-date information, backed by lists of detailed references, on such subjects as aerial photography, photogrammetry, high-speed and time-lapse photography, nuclear track recording, electron photomicrography, phase-contrast technique, and stress analysis with polarised light. There is an article on the instructional use of visual aids, another on the use of the camera in connexion with time and motion study. Information on the photographic industry is also included; there is a list of photographic organisations (unfortunately their addresses have been omitted) and a section deals with photographic standards in Britain, the U.S.A., France, and Germany. The volume, edited by Dr. D. A. Spencer with the assistance of a strong editorial board, is well up to the standard expected of the Focal Press, which has established an enviable reputation by the quality of its books on photography.

Far and Near

Oersted's Centenary

MARCH 9 marks the passing 100 years ago of Hans Christian Oersted, the Danish philosopher whose name is perpetuated in electromagnetism and in a unit. In our schooldays we first heard of Oersted's classical experiment, in which a magnetic needle is deflected by an electric current flowing in a wire placed either above or below the needle. That simple experiment, a first indication of the connexion between magnetism and electricity, brought the galvanometer and other current-measuring instruments. It was carried out in 1819—after Volta's discovery and while Faraday was as yet still engaged with chemical researches at the Royal Institution.

Yet to mention Faraday's chemistry is to bring to mind one point ignored by encyclopaedist-biographers. Oersted, winner of the Royal Society's Copley Medal for his work on electromagnetism, was more versatile as a man of science, being pharmacist and doctor of medicine (by graduation at Copenhagen)—and chemist. This once poor apothecary's apprentice lectured on chemistry at Copenhagen while managing a pharmacy. Furthermore, the history of aluminium must include Oersted's other classical experiment, or rather it would be a classic, were it not so regularly forgotten. The first chapter in aluminium history is usually related as beginning with Wöhler's preparation of the metal but it should begin with Oersted's prior claim of 1825. He prepared anhydrous aluminium chloride by heating a mixture of the oxide with charcoal while passing a current of chlorine over the mass. The chloride was then reacted with a 15% amalgam of potassium so that potassium chloride and free aluminium were formed, the latter remaining in the mercury. "By distillation of this without contact with the atmosphere" wrote Oersted, "it forms a lump of metal which in colour and lustre somewhat resembles tin." He hinted at "remarkable properties . . . showing promising prospects of important results"—a prediction since fully borne out. Although Wöhler stated that on repeating this experiment the whole amalgam volatilised on distilling it, he was wrong and we have conclusive evidence to prove that aluminium can be prepared in this way.

"Life Begins Tomorrow"

A FILM which has been described as the most significant for 50 years has just been released under the new X certificate of the British Board of Film Censors, which means that it cannot be shown to children under 16. *La Vie Commence Demain* should most properly be described as a documentary. A young man up from the country is persuaded that a sight-seeing visit to Paris should not be merely a tour of past greatness but should be concerned with the vital exciting present and the even more exciting future. He meets in turn Jean-Paul Sartre, Daniel Lagache, Jean Rostand, Le Corbusier, Picasso, and André Gide, and he goes to a Unesco conference; André Labarthe is his guide. (The Joliot-Curies were cut out of the British version of the film.) During these interviews the pattern of a world where science and technology achieve the seemingly impossible emerges. Even in his interview with the famous writer André Gide, the young man finds him (Gide) entertained by the uses of the dictaphone. What is the reaction of the young man-in-the-street to all this? Perhaps fortunately for him his glimpses into this brave new world of science are conveyed by word of mouth from the great men he meets. Unfortunately for us we actually see how man's mastery of the functioning of the brain, of the predetermination of sex and even of the artificial creation of life itself might be achieved. He is persuaded that a man who feels himself at variance with the present epoch might find some comfort from comprehending the revolution in thought which might take place in the next hundred years. Others might feel that more comfort could be found in a quiet and rational contemplation of the past. It cannot be denied that the film is stimulating and superbly directed, but, in its full implications, it is just as horrible as, say, Aldous Huxley's *Brave New World* or Orwell's *1984*.

Atom Bombs for U.S. Army?

REPORTS from Las Vegas, Nevada, indicate that intensive testing of atomic weapons are in progress. The U.S. Atomic Energy Commission has proving grounds 100 miles N.W. of Las Vegas, and a series of five atomic explosions took place there within 11 days. It is suggested that among other weapons under test is a miniature atomic bomb designed for use in support of ground forces as opposed to air forces.

Correction

IN our February issue ("Maleic Hydrazide may Cause Mutations", p. 37), Dr. Koller referred to the commercial preparation called 'Barsprout', which is being used to stop stored onions and other vegetables from sprouting. We have checked the quoted reference to 'Barsprout' (*Science*, 1950, 112, p. 597), and find that this is a dust containing the methyl ester of α-naphthyl acetic acid; it is *not* maleic hydrazide, as was stated in Dr. Koller's letter.

Giant Telescope for South Bank Exhibition

A 74-INCH reflecting telescope, one of the six largest in the world, will be one of the most outstanding exhibits in the Dome of Discovery, at the South Bank Exhibition of the Festival of Britain. The telescope will be on view as an exhibit only; visitors will not be able to "look through it".

The instrument, based fundamentally on Newton's reflecting principle and built to British design by British craftsmen, is being made by Sir Howard Grubb Parsons & Co., for the Australian Commonwealth Observatory at Mount Stromlo, near Canberra.

The only other similar instrument of comparable size in the southern hemisphere is a telescope which has been in use at the Radcliffe Observatory, Pretoria, S. Africa, since 1948. (See the article by Dr. David S. Evans on this instrument, DISCOVERY, Aug. 1948, p. 251.) Experience with this has led to some modifications in design of the new instrument.

The lattice-work telescope tube is some 30 ft. long and 8 ft. in diameter; the moving parts weigh about 40 tons; yet so freely does it turn and so well is it balanced that the slightest push will move it.

The reflecting mirror of glass, surfaced with a very thin polished film of aluminium has the clear aperture of 74 in. The mirror at the exhibition will be a dummy.

U.N. Technical Assistance Programme: £2000-a-year Experts Needed.

TAX-FREE salaries of over £2000 a year, plus allowances, will be paid by Unesco to suitable British experts.

They are urgently wanted in connexion with Unesco's task under the United Nations' $20 million Technical Assistance Programme. Unesco's share of this fund is nearly $2½ million, most of which will be used to send advisory missions and teams of experts to under-developed countries to organise their education systems, to found university faculties, research institutes and adult education centres, and to establish schools of technical and vocational training.

The posts are of one to three years duration and carry tax-free salaries of $7000 to $8000 a year, with lodging provided by the host country. Highly qualified persons are required, with university degrees and several years of practical experience in their particular fields.

So far 36 posts have been created in such countries as Ceylon, Indonesia, Iraq, Liberia, Mexico, Thailand and Ecuador. Examples of the kind of jobs available are: Mexico—Director of the Scientific and Technical Documentation Centre, Ph.D. in Science or equivalent degree, good knowledge of Spanish preferred; Iraq—Industrial Chemistry expert for Faculty of Science, Baghdad.

Persons wishing to know more about these posts should send brief particulars of their qualifications and experience to the National Commission for Unesco, Ministry of Education, 11 Bryanston Square, London, W.1.

Prize for Science Writing

THE International Council of Scientific Unions has been asked to consider the organisation of an international prize for science writing. An annual sum of £100 has been offered to Unesco by the Indian industrialist, Mr. B. Patnaik, to stimulate good science writing, and a prize to be known as the Khalinga Prize for Science Writing is to be instituted. This prize could well be used to encourage *popular* science writing, and it is to be hoped that this suggestion will be implemented in the near future. The originator of the idea for a Unesco prize for science writing was, we believe, Maurice Goldsmith, who was a frequent contributor to DISCOVERY before he joined the staff of Unesco.

Pan-Indian-Ocean Science Congress

THE first session of the Pan-Indian-Ocean Science Congress was held in the Indian Institute of Science, Bangalore, between January 2 and 10. The Prime Minister of India, Pandit Nehru, inaugurated it in a colourful ceremony which was attended by delegates from Australia, New Zealand, Burma, Malaya, Ceylon, Madagascar, Netherlands and Portugal. Leading scientists from Britain included Prof. P. M. S. Blackett, Prof. R. S. Peierls and Prof. L. Rosenfeld; Prof. F. Perrin (French Atomic High Commissioner), Prof. L. Fieser, and Prof. G. Wentzel of the U.S.A. also attended.

The increasing importance of science in the Far East was recognised in a proposal for holding a congress of scientists of the countries around the Indian Ocean for solving common problems of mutual interest. The Government of India evinced keen interest and invited the first session to India. Dr. H. J. Bhabha, the cosmic ray expert and president of the Indian Science Congress, was elected the first president of the Congress.

The delegates presented 19 technical papers, the bulk of which came from Australia. The delegates also gave a number of popular lectures which were highly appreciated.

At a meeting of the Pan-Indian-Ocean Science Congress, the interim constitution of the organisation was drafted after considerable discussion. It was decided that the congress will meet at intervals of not less than two years, and the next meeting is scheduled to take place in Australia in the middle of 1953. The General Council consists of the following: Dr. H. J. Bhabha (India), *president*, Prof. A. D. Ross (Australia), Dr. Ba Thi (Burma), Dr. N. G. Baptist (Ceylon), Prof. J. Millot (Madagascar), Prof. Robinson (Malaya), Prof. H. A. Ferreira (Portugal) and Dr. B. Sanjiva Rao (India), *secretary*.

Membership of the Congress will be open to independent countries bordering the Indian Ocean, and the Congress will undertake co-operative work in various fields of science. In the physical sciences recommendations will be made by the participating countries for new research work of potential significance. In the biological sciences a section will be devoted to matters connected with public health and nutrition, and liaison will be established with international organisations like W.H.O. In the agricultural sciences, to increase agricultural production and raise the living standard of the peoples, it was decided to have a free exchange of personnel and information. In the social sciences, population studies, education, cultural amenities, national incomes and related estimates will be undertaken and sample surveys conducted. For furthering fundamental knowledge about the Indian Ocean, in all its aspects, the Congress urged close co-operation in studying geography and oceanography between the Governments of the countries bordering the Indian Ocean.

In concluding the session, the President said that much could be done by close scientific co-operation between different countries. Dr. Ross said the countries bordering the Indian Ocean had many common scientific problems and mutual help would result in raising the national prosperity of the various countries.

N. R. SRINIVASAN.

More Money for Medical Research Workers

A MAJOR VICTORY for the Association of Scientific Workers is reported in the Jan. 1951 issue of that union's journal. It concerns the matter of salaries paid to the scientific staff of the Medical Research Council.

A regrettable decision of the M.R.C. had resulted in medically qualified research staff receiving back-dated salary increases, whereas no authority had been given for similar increases to other scientific workers employed by M.R.C. The upshot was that a large proportion of the scientific staff of the M.R.C. at Mill Hill and elsewhere joined the A.Sc.W., which proceeded to raise the matter of salaries with the Ministry of Labour. The dispute went to arbitration, when the interesting point emerged that the M.R.C. as the employing body fully agreed that salary increases should have been granted regardless of whether the individual scientist was medically qualified or not. The Treasury has now agreed to increase the salaries of all scientific staff employed by the M.R.C.

The A.Sc.W. is now congratulating itself that its intervention had far greater effect upon the Treasury than had "the well-meant efforts of the (Government's) Medical Research Council"!

Atomic Energy Development in France

PROF. FRANCIS PERRIN has been installed as head of the French atomic energy project, the post from which FRÉDÉRIC JOLIOT-CURIE was deposed by the French Government because of his Communist affiliations. The American journal *Time* has this comment to offer on Perrin's appointment:

"Behind Socialist Perrin's triumph some thoughtful folk professed to see a measure of Communist manoeuvring. Joliot-Curie heads the nuclear chemistry laboratory at the Collège de France, and Perrin the experimental physics laboratory at the same institution. American visitors have reported remarkable goings-on at the Collège. Physicist Alexander Zucker of the Oak Ridge, Tenn. National Laboratory wrote in the current issue of *Physics Today*: 'There is a Communist cell meeting every week. . . . Laboratories in Paris are known by their political affiliations rather than by the work they do. Thus we have Clerical laboratories, Communist laboratories, Socialist laboratories. . . .'

"Although Socialist Perrin is not suspected of being a Communist or a fellow-traveller, he is certainly more acceptable to the Reds than Thibaud, who is an outspoken anti-Communist. When a learned scientific paper by Thibaud reporting a discovery concerning atomic nuclei was submitted to the Academy of Science, observers considered it more than a coincidence that two bright students of Joliot-Curie should immediately produce papers reporting similar findings. Their papers, forwarded to the academy by Joliot-Curie, switched the limelight from Thibaud, who had been getting a big play in the non-Communist press. Thibaud was furious. He protested to the academy; then wrote to the Atomic Commission resigning an appointment to its Scientific Council. 'There is no more science in France.' Thibaud told reporters hotly, 'science has become nothing but politics.'"

Joliot-Curie's wife, MADAME IRENE JOLIOT-CURIE, has been dismissed from the French Atomic Commission. She is a daughter of Madame Curie, discoverer of radium, and she and her husband shared the Nobel Prize for Chemistry in 1935.

Night Sky in March

The Moon.—New moon occurs on March 7d 20h 50m U.T., and full moon on March 23d 10h 50m. The following conjunctions with the moon take place:

March			
9d 10h	Mars in conjunction with the moon	Mars	2° S.
10d 06h	Venus	,, Venus	3° S.
23d 08h	Saturn	,, Saturn	4° N.

In addition to these conjunctions with the moon, Mercury is in conjunction with Mars on March 26d 09h, Mercury being 1·3° N.

The Planets.—Mercury, in superior conjunction on March 11, is too close to the sun for favourable observation during most of the month, but towards the end of March the planet sets more than 1½ hours after sunset and is visible in the western sky. Venus sets at 19h 55m and 21h 30m on March 1 and 31 respectively, and is visible for some hours after sunset, stellar magnitude −3·4 and the visible portion of the illuminated disk varying between 0·91 and 0·84. Mars is an evening star, setting at 19h 20m and 19h 30m on March 1 and 15 respectively, but is gradually approaching the sun and at the end of the month sets about an hour after sunset, when it is becoming unfavourably placed for good observation. Jupiter is in conjunction with the sun on March 11 and is not well placed for observation; later in the month it becomes a morning star rising at 5h 25m at the end of March —15 minutes before sunrise—and will not be well placed for observation till late in April. Saturn rises at 19h 25m and 17h 10m on March 1 and 31 respectively, and is visible throughout the night. The planet is in opposition to the sun on March 20, which implies that about that date the sun sets near the time of Saturn's rising.

An annular eclipse of the sun takes place on March 7, but is invisible in the British Isles; it is mostly visible in the southern hemisphere, but has not very much interest for astronomers—unlike a total eclipse.

Spring Equinox is on March 21d 10h when the days and nights are of equal length—12 hours—over all the world. About this time notice how much later the moon rises each night; it exceeds 1h 20m on March 21-22 and reaches over 1½ hours between March 25 and March 26 in the latitude of Greenwich.

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